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Technologies and Management Strategies for Hazardous Waste Control

Volume II—Working Papers

Part C

Classification by Degree of Hazard for Selected Industrial Waste Streams

April 1983

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Preface

This volume contains papers written for OTA to assist in preparation of the report *Technologies and Management Strategies for Hazardous Waste Control.* OTA does not endorse these papers. In several instances, the OTA report reaches somewhat different conclusions because of additional information which was obtained later. These papers, however, may prove valuable for readers needing more detailed or specific information than could be accommodated in the final assessment report, and are being made available for such purposes.

CLASSIFICATION BY DEGREE OF HAZARD
FOR
SELECTED INDUSTRIAL WASTE STREAMS

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EXECUTIVE SUMMARY

INTRODUCTION: THE CONTEXT OF THE STUDY

The most immediate objective of the Resource Conservation and Recovery Act (RCRA) and its attendant regulations was to address the imminent problems associated with insufficiently regulated hazardous waste management activities. In response to this requirement the U.S. Environmental Protection Agency (EPA) formulated a regulatory approach to hazardous waste management which promoted blanket public health protection from all potentially harmful waste management activities independent of a detailed consideration of comparative hazard potential. It was considered that this regulatory framework would provide an immediate vehicle for addressing the most urgent waste-related environmental and public health concerns. Once these priority concerns were addressed, the regulatory strategy could be re-examined and fine-tuned to improve public health and environmental protection, enhance regulatory efficiency, and accommodate waste management economy.

Since the passage of RCRA, considerable effort has been devoted to the study and evaluation of the environmental and public health ramifications of waste management options. We are continually improving our understanding of constituent mobility and toxicity; our ability to establish sensible priorities based on hazard potential; and our capacity to predict waste-related problems. The next logical step is to apply this growing body of knowledge to the refinement of the existing hazardous waste regulatory program.

One frequently suggested regulatory reform strategy involves (1) the development of a graduated scale for classifying the hazard potential of different waste disposal situations; and (2) the establishment of management standards commensurate with those classifications. This strategy, which embraces a variety of hazard assessment methods, is commonly referred to as the "degree of hazard" concept. The underlying objectives of instituting a degree of hazard-based regulatory program are (1) to identify and recognize those waste management situations which pose the greatest threat to public health and environmental resources; (2) to focus management attention on those waste disposal situations which suggest the greatest hazard potential; (3) to minimize over-regulation of low hazard waste management activities; and (4) to promote a more discriminating allocation of existing and potential waste management resources.

Proponents of the degree of hazard regulatory approach have argued that its implementation would foster improved public health protection as well as waste management economy. Opponents of the concept maintain that the level of complexity required to satisfactorily address degree of hazard makes the approach administratively unmanageable. To date, the debate over the validity and applicability of degree of hazard to nationwide waste regulation has been conducted in the absence of a documented application of hazard assessment methods to actual waste streams in typical disposal environments. The purpose of the "Classification by Degree of Hazard for Selected Industrial Waste Streams" program was to apply existing degree of hazard assessment methods to actual case study industrial waste disposal situations. These case study applications would then provide a context for assessing the advantages and disadvantages of applying various elements of hazard assessment approaches to nationwide waste classification efforts. Case study examples would also provide a framework for the development of regulations tailored to match specific hazard categories. This report presents the results of case study applications of three degree of hazard assessment methods to eight industrial waste streams.[1]

STUDY APPROACH

The study involved the following five basic work elements:

- Selection of case study waste streams;
- Selection of degree of hazard schemes;
- Data collection;
- Scheme computation; and
- Analysis of results.

Waste Stream Selection

The criteria for selecting case study waste streams included:

- Wastes empirically characterized as presenting high hazard potential must be represented;
- Wastes empirically characterized as presenting low hazard potential must be represented;
- Wastes representative of each of the following four categories must be included:
    - High volume/high toxicity
    - High volume/low toxicity
    - Low volume/high toxicity
    - Low volume/low toxicity[2]

---

[1] Background information was developed for nine case study waste streams but facility-specific information was unavailable for one stream which limited the sample to eight waste streams.

[2] For study purposes high and low volume were defined as >250,000 tons/yr (on a nationwide basis) and <5,000 tons/yr respectively. Any annual volumes of 5,000-25,000 were classified as medium volume. Highly toxic was defined as containing a waste constituent that is carcinogenic and/or has an oral rat LD_{50} of <400 mg/kg. Low toxicity was defined as containing no waste constituent with an oral rat LD_{50} <15,000 mg/kg.

After identifying a series of candidate waste streams from the four basic categories above for which adequate data exist, the project team sought to select as diverse a sample as possible according to the following criteria:

1. Number of toxic constituents in the waste stream (one vs. multiple).

2. Number of EPA-defined hazardous characteristics in the waste stream (toxic only vs. toxic and ignitable, corrosive or reactive).

3. Representation of the spectrum of several hazard characteristics in the study sample (highly persistent substances vs. non-persistent substances; carcinogenic substances vs. non-carcinogenic toxic substances).

4. Potential for treatment/disposal by technologies other than landfilling (e.g. incineration).

5. Concentration of a specific toxic constituent in two or more waste streams (high concentration vs. low concentration).

6. Degree of standardization of industrial processes and waste component ratios (standardized vs. variable processes).

7. Representation of organic vs. inorganic toxic constituents.

Over 50 waste streams were considered for inclusion in the study, from those, nine were selected. The nine preliminary waste streams were grouped empirically into hazard categories as follows:

1. High Volume/Low Toxicity

   o Wastewater treatment sludge from the production of titanium dioxide (TiO_2) pigment using chromium-bearing ores by the chloride process. (EPA issued a generic delisting of this waste in October 1980. Thus this waste represents a waste of low hazard potential according to current EPA criteria.) (K074)

2. High Volume/High Toxicity

   o Bottom stream from the acetonitrile column in the production of acrylonitrile. (K013)

3. Medium Volume/High Toxicity

   o Brine purification muds from the mercury cell process in chlorine production where separately prepurified brine was not used. (K071)

4. Low Volume/Low Toxicity

   o Light and heavy ends from the distillation of acetaldehyde in the production of acetic anhydride. (Not listed by EPA)

5. Low Volume/High Toxicity

- Chlorinated hydrocarbon wastes from the purification step of the diaphragm cell process using graphite anodes in chlorine production. (K073)
- Wastewater treatment sludge from the production of toxaphene. (K041)
- Distillation bottoms from the production of nitrobenzene by the nitration of benzene. (K025)
- Ammonia still lime sludge from coking. (K060)
- Spent stripping and cleaning bath solutions from electroplating operations where cyanides are used in the process (except for precious metals electroplating spent stripping and cleaning bath solutions). (F009)

Degree of Hazard Assessment Scheme Selection

The criteria for selecting degree of hazard schemes addressed potential scheme applicability to nationwide waste management regulation. Only those schemes which involved a logical, responsible and scientifically defensible approach were considered. In addition, the project team sought to select schemes which presented a unique dimension of hazard assessment with potential applicability to a nationwide program. The following three schemes were selected for evaluation:

- The State of Washington Department of Ecology Waste Classification Scheme;

- The State of Michigan Department of Natural Resources Waste Classification Scheme; and

- The JRB Associates Environmental Containment Waste Characterization Scheme.

The Washington and Michigan Schemes have several elements in common, including the following:

- They provide management designations which prequalify facilities for regulation.

- They employ toxicity rating methods based not on waste stream properties, but on toxic constituent properties.

- They provide specific standards and criteria for evaluation.

- They consider waste quantity in management categorization.

- They consider constituent concentration in management categorization.

- They do not involve an evaluation of environmental suitability in facility management category designation.

The Washington Scheme is unique in that it involves the calculation of a single summary value representing the relative toxicity of a waste stream with multiple constituents. This summary value is called the waste's "equivalent concentration."

The Michigan Scheme is unique in that it involves the calculation of a hazard value for a single constituent which is based on the consideration of several waste characteristics in addition to toxicity.

The JRB Associates Scheme is unique in that it weighs environmental factors and waste management practices heavily in hazard assessment.

The general attributes of each of these hazard assessment methods are described briefly in the following subsections.

The State of Washington Department of Ecology Waste Classification Scheme

Under the Washington scheme, waste constituents are categorized according to their toxicity as defined by five sets of criteria relating to four test measures. Once the toxicity categories are established for the complement of waste constituents, an "equivalent concentration" is calculated for the waste stream. Equivalent concentration is calculated by applying weighting factors to the five levels of toxicity and summing the concentrations of constituents and their multipliers. While this method seeks to consider the combined toxicity of a variety of substances, it does not profess to address synergistic or antagonistic effects of component substances.

Once the equivalent concentration is determined for a waste stream, it is plotted against waste quantity on a graph which is partitioned to define management categories, or levels of regulation. Thus the plotting of equivalent concentrations against waste quantity results in a management designation.

The Washington scheme considers carcinogenicity and persistence in a similar fashion (relating quantity and concentration) based on the presence of halogenated hydrocarbons and polycyclic aromatic hydrocarbons.

The Washington scheme identifies three management levels: undesignated, dangerous waste, and extremely hazardous waste.

The State of Michigan Department of Natural Resources Classification Scheme

Under the proposed Michigan scheme[1], waste constituents are categorized based on a numerical ranking formula which addresses seven constituent attributes:

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[1] Although proposed, this scheme was never approved for incorporation in the Michigan Hazardous Waste Management Regulation.

- Acute toxicity;
- Carcinogenicity;
- Hereditary mutagenicity;
- Teratogenicity;
- Persistence;
- Bioaccumulativity; and
- Other adverse effects.

Each constituent receives a score for each category for which data are available. A formula which incorporates a weighting scale is then applied to the pattern of scores from which a toxicity determination is figured. The constituents are not ranked according to their cumulative scores. The scheme makes no provision for offsetting the low scores characteristically assigned to constituents for which data are unavailable.

Once toxicity scores are assigned, the constituent concentrations are plotted against waste quantity volumes on graphs specific to the individual hazard categories. If any constituent is plotted in the managed category, the waste is managed under the Michigan State Act 64. Michigan identifies only two management levels; managed under Act 64 and not managed under Act 64.

JRB Associates Environmental Containment Waste Characterization Scheme

One criticism often leveled at the degree of hazard approach to hazardous waste assessment and regulation concerns the concept's traditional lack of consideration of those site-specific parameters which factor into hazard potential. The articulation of the generic properties of a waste stream, and the designation of its dangerousness relative to other wastes, can suggest priority considerations for the selection of safe, economical disposal options. However this information, independent of an evaluation of site-specific environmental features, cannot provide a realistic measure of the hazard of a particular waste disposal situation. The JRB scheme exemplifies one manner of addressing key site variables which influence hazard potential owing to their relevance to the ultimate fate and effects of hazardous waste constituents.

The JRB Classification Scheme was originally designed to evaluate land disposal sites containing hazardous wastes to rank them for remedial action priority. This approach stands somewhat apart from the degree of hazard concept, and yet the method does have potential applicability to degree of hazard assessment. This system involves the consideration of 31 site- and waste-specific variables which are grouped into four categories:

1. Waste Characteristics: the consideration of the types of potential hazards posed by the wastes;

2. Waste Management: the consideration of the quality of facility design, construction, and operation;

3. Pathways: the consideration of mechanisms of contaminant migration;

4. Receptors: the identification of potential targets of chemical hazards.

A site is assigned a score of 0 to 4 for each of the 31 parameters. Each of the variables has an assigned multiplier (weighting factor). Thus the score is multiplied by the weighting factor and a sum total factor score is computed for each of the four evaluation categories. These factor score summaries are divided by the maximum possible score and multiplied by 100. The higher the score the higher the hazard potential. For each category the percentage of missing values is calculated and presented to provide a measure of score reliability. A summary score for the entire facility is calculated in the same fashion as the four category scores.

DEGREE OF HAZARD DETERMINATIONS: PROBLEMS

In the course of computing the degree of hazard classifications, problems were encountered relative to data availability, data variability, and data interpretability. For several of the more than 30 constituents present in the case study waste stream samples, there were insufficient data to rank the substances with confidence. In some cases the literature reported values for various toxicity tests, but the reported tests were not those required for hazard classification. Because there is no formula to standardize various measures of toxicity by correlating test results, the data in these cases could not be applied to hazard classification. For example, there is no established value for an oral dog LD_{50}[1] that can be translated into an oral rat LD_{50} for purposes of ranking chemicals' relative toxicity. Similarly, there is no value for oral rat LD_{50} that correlates with confidence to an inhalation rat LD_{50} value.

Data availability will continue to be a problem in degree of hazard assessment as new chemicals are continuously introduced into the environment. Acceptable degree of hazard approaches must acknowledge this limitation and provide for a measure of uncertainty in hazard interpretation. The Michigan scheme makes no provision for data gaps and as a result constituents sometimes received low hazard ratings which might not in fact correspond to a low hazard situation. The JRB scheme provides a measure of uncertainty to facilitate relative hazard interpretation.

Data interpretability emerged as a problem because some of the defined hazard categories, particularly in the Michigan scheme, are more specific than the data reported in the commonly available literature compendia. These problems point up the importance of developing a scheme that reflects the nature of the available summary literature and that specifies the appropriate data sources for consultation. All investigators or managers applying the scheme to wastes should access the same body of literature.

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[1] Oral route of exposure, lethal dose, 50% of sample.

DEGREE OF HAZARD DETERMINATIONS: RESULTS

The degree of hazard schemes effectively distinguished categories of wastes. As would be expected, the categories of wastes so distinguished reflected the fundamental assumptions underlying the schemes. For example, the influence of toxic constituent concentration is considerable in the computation of both the state schemes. If the constituent concentration guidelines are scientifically defensible, the methods do distinguish high and low hazard wastes on this basis. By contrast, the JRB scheme does not address constituent concentration in its toxicity evaluation. The influence of this scheme element is apparent in the relative scores for various facilities. The most heavily weighted factors evaluated by the JRB scheme concern the population within 1,000 feet (multiplier of 12) and distance to nearest drinking water well, offsite building and surface water (multiplier of 8 for each). The assumptions that these considerations are high priority issues is reflected by the JRB scheme scores.

SCHEME DEVELOPMENT

Any defensible national degree of hazard scheme must be based on a balance of sound scientific principles and adinistrative feasibility. Every scheme will have a bias. The bias must emphasize those characteristics which have the greatest influence on hazard potential in the context of protection of public health and environmental resources. Criteria should be explicitly stated for the adoption of any element of a scheme. Where interdependent variables are factored into hazard assessment (e.g., quantity/concentration relationship), the rationale behind that element of scheme design should be documented. The administrative mechanisms established to regulate facilities and wastes based on an array of variables and relationships should be realistic in scope and complexity.

The Classification by Degree of Hazard Project provided an opportunity to test a concept which was previously only a topic of conjecture. The anticipated difficulties inherent in the task of applying the toxicological data base to the practical task of regulatory design were confirmed. While the limitations of this data base for practical applications are acknowledged, the possibility of using it to promote regula tion by prequalification rather than exemption through disqualification emerged as a possible regulatory option.

The current Federal program imposes blanket regulatory coverage for all facilities generating certain wastes, allowing only after-the-fact exclusions for those facilities that successfully complete the delisting process. The delisting process is time-consuming and expensive, and basically considers degree of hazard factors in the granting of variances.

A nationwide program incorporating a variable exclusion provision based on degree of hazard might focus regulatory resources more efficiently on those waste disposal situations which pose the greatest hazard to public health and environmental quality. Given the diminishing resources available for regulatory guidance and enforcement, this approach may prove appealing, both environmentally and economically. It would place the regulatory burden on industry in the initial waste evaluations, but this burden might prove to be less expensive, less time-consuming, and less hampered by uncertainty than the current delisting process.

Once the hazard classifications are assigned we are still left with the task of linking hazard category to waste management requirements. The development of a regulatory decision tree or formula to lead waste managers directly from hazard assessment to safe and economical management responses is an unrealistic expectation. Management requirements and levels of environmental control are disposal option-specific, not degree of hazard-specific. Management requirements address waste characteristics, not hazard levels. If any particular industry group stands to benefit from implementation of a hybrid scheme based on the hazard assessment principles examined in this study it will be those generators/disposers of streams with very low concentrations of toxics; very low waste quantities; or facilities which are sited away from population centers and within suitable environmental settings.

Although the feasibility of providing management formulae specific to situations of graduated hazard potential may be questionable, regulatory precedents, which might suggeest an avenue for fostering regulatory relief, do exist. As an example, the dredge and fill permit program of the U.S. Army Corps of Engineers offers a hierarchical approach to the regulation of construction and related activities in navigable waters. This program is by no means a potential prototype in its content; merely its framework.

At the end of the spectrum of activities representing the lowest hazard potential, the Corps' regulations provide criteria defining projects which are permitted on a nationwide basis without individual permit review. In the middle of the spectrum the Corps issues General Permits on a district by district basis. General permits outline activities which can be undertaken in a particular region without extensive permit review provided they meet specific design and environmental criteria. The project criteria for these categories of activities are drawn up by the Corps so as to provide environmental protection and reduce regulatory burden on individuals undertaking these low impact projects. At the highest hazard end of the spectrum are projects requiring individual review and comment because of their potential for environmental disruption. Thus, theoretically at least, the regulatory agency's time and resources are expended in consideration of those proposals characterized as having the greatest hazard potential. This type of regulatory model may provide a logical link between degree of hazard assessment and the provision of a management framework.

This report provides a context for the discussion of the feasibility and defensibility of applying the degree of hazard concept to national waste regulatory initiatives. It recommends a framework for incorporating degree of hazard in national hazardous waste management that suggests the following advantages:

- It reduces regulatory burden on low hazard facility operations;
- It provides predictable and definitive criteria to guide industrial managers;
- It allows the use of low to moderately trained personnel to perform initial screening activities;
- It concentrates the efforts of highly trained professionals on the most hazardous situations and on a limited number of facilities defined as high hazard;
- It is objective and reduces the possibility of capricious permitting decisions;
- It is based on sound technical arguments relating to hazard potential;
- A specific set of criteria could be established for each waste management option (e.g., incineration, landfilling) so that degrees of hazard would be management option-specific; and
- A specific set of criteria could be established for pre- and post-treatment for wastes that pose handling rather than disposal hazards.* Once a non toxic, but perhaps corrosive waste were treated so as not to be corrosive, it could be classified as low risk.

The knowledge exists to design and implement a hazard-based regulation. The success of such an undertaking is heavily dependent on the combined efforts and cooperation of industry and government. While the data-related caveats are evident and require responsible treatment, the primary obstacle to implementing degree of hazard may involve the willingness of industry and government to work together to create a responsible regulatory strategy.

CHAPTER 1

INTRODUCTION

Many scientists and industrial plant managers contend that existing national hazardous waste management policies could be improved by (1) considering hazard potential in waste classification, and (2) developing management standards commensurate with those classifications. Proponents of the "degree of hazard" concept argue that such consideration could focus waste management regulation more effectively on those wastes and waste management practices that pose the greatest threat to public health and environmental quality, while simultaneously reducing the non-productive regulatory burden on environmentally non-threatening situations. The envisioned outcome of implementing a degree of hazard approach would be improvement of the level of environmental protection afforded by regulation, more responsible allocation of the nation's limited hazardous waste treatment and disposal resources, and improvement of the cost/benefit ratio of the national regulatory program.

Several approaches to degree of hazard waste assessment have been proposed and several actual degree of hazard methodologies have been developed. Notable examples of existing degree of hazard schemes include the following:[1]

- State of California Method;
- State of Rhode Island System;
- State of Texas, Department of Water Resources Approach;
- State of Washington, Department of Ecology Classification System; and
- State of Michigan Department of Natural Resources Rank-Order System.

Some of these methods address waste constituent toxicity, persistence, mobility and other parameters which influence the potential for population exposure to dangerous substances. Some approaches gauge hazard potential by the volume of waste generated and the concentration of dangerous substances in the waste. Methods are currently being developed to incorporate in hazard assessment an evaluation of disposal site features and management practices which further define the comparative hazards inherent in different waste disposal situations. The degree to which different formulae for addressing these variables can provide environmentally defensible and economically practical hazardous waste management guidelines deserves serious attention.

Since passage of the Resource Conservation and Recovery Act (RCRA), the industrial waste management community has debated the validity and applicability of a degree of a hazard approach to national waste regulation. This debate has been conducted without the benefit of documented applications of degree of hazard assessment methods to actual waste streams in typical waste disposal settings. The purpose of this study is to provide actual case study degree of hazard assessments of real world disposal practices. These case studies can provide a basis for evaluating the potential for degree of hazard schemes to distinguish high hazard from low hazard disposal practices; to define and address waste management priorities; and ultimately to provide a basis for establishing appropriate levels of waste management regulation.

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[1] An overview of these schemes is provided in: U.S. Congress Office of Technology Assessment, Nonnuclear Industrial Waste Classifying for Hazard Management Washington, D.C., November 1981.

THE IMPORTANCE OF ADDRESSING SITE-SPECIFIC VARIABLES IN HAZARD ASSESSMENT

One criticism often leveled at the degree of hazard approach to hazardous waste assessment and regulation concerns the concept's traditional lack of consideration of those site-specific parameters which factor into hazard potential. The articulation of the generic properties of a waste stream and the designation of its dangerousness relative to other wastes can suggest priority considerations for the selection of safe, economical disposal options. However this information, independent of an evaluation of site-specific environmental features, cannot provide a realistic measure of the hazard of a particular waste disposal situation. The following brief discussion of fate and effects issues is designed to clarify the importance of addressing both site- and waste-specific characteristics in hazard assessment. Land disposal is used as an example, although similar arguments can be put forth for other treatment and disposal technologies.

FATE AND TRANSPORT OF WASTE CONSTITUENTS

A waste poses no health or environmental hazard until it is released to the environment. Once it is released, its hazard potential is determined by its mobility in the environmental media, the barriers to its movement, its persistence in the environment, its toxicity and carcinogenicity, and its accessibility to target organisms. Table 1 summarizes the basic site and waste relationships that provide the framework for evaluating land disposal situations.

TABLE 1

BASIC RELATIONSHIPS DEFINING FATE AND TRANSPORT
OF HAZARDOUS WASTES IN LANDFILL SITUATIONS

Factor	Determinant
Waste Release	Adequacy of disposal and waste containment procedures
Constituent mobility	Availability of transport media; tendency of constituent to enter transport media
Constituent persistence and bioaccumulation	Biodegradability; physical/chemical degradability; bioconcentration potential
Realization of hazard to public health or the environment	Accessibility of constituents to receptors; concentration and duration of exposure; toxicity, carcinogenicity, and other factors

Waste Release

The adequacy of waste disposal and containment procedures used in the secure landfilling of chemical wastes has an enormous impact on the potential for waste release. Prior to landfilling, waste streams are often segregated or aggregated depending on waste compatibilities, dewatered or bulked with drier compatible wastes, and then stored until deposited. Separate disposal cells may be provided for each group of compatible wastes. When the cells are filled they are closed, and the containment design features are activated. These features may include a clay cap to minimize the volume of water entering the cells, leachate and gas migration control systems to minimize exchange between cells, and leachate and gas collection systems to remove liquid and gas accumulating within the confines of the cell. Ideally, the containment features should isolate the landfilled material from the environment. In actuality, construction and design limitations, the finite life span of materials, and the reactivity of the contained substances all combine to make perpetual containment an engineering challenge, and groundwater monitoring essential to provide for public health protection.

Constituent Mobility

Constituent mobility is a function both of the availability of a transport medium and of the tendency of the constituent to enter the medium. Water stored within the fill or entering the fill, even in small quantities, can serve as a transport medium, as can liquids buried in the landfill.[1] The tendency of a constituent to enter the aqueous phase is measured by its solubility. The preference of a constituent for an organic solvent as opposed to water is measured by partition coefficients such as the octanol:water coefficient (K_{OW}). The greater the value of the coefficient, the greater the tendency to dissolve into octanol, an indicator organic solvent. For example, acrylonitrile is highly soluble in water but not in octanol; hexachloroethane is only slightly soluble in water but highly miscible in octanol.

It is almost impossible to prevent the accumulation of water in a landfill. The water will be derived from internal as well as external sources. Thus hazardous constituents that are highly soluble can be transported from the landfill as leachate removed by the control system or as permeate through the liner. Eg., some organic compounds with high values of K_{OW} have been associated with the shrinking and cracking of clay, or the destruction of synthetic liners. These processes result in breakthrough of liners, and bulk transmission of the medium and its burden of hazardous constituents from the landfill[2]. The important conclusions here are that liners, whether clay or synthetic, have finite lives that can be limited by improper disposal of organics, and that the complete elimination of releases of hazardous constituents even from a modern landfill is impossible to assure.

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[1] Landfilling of liquids is no longer permitted under USEPA regulations

[2] William J. Green, et al., "Clay-soils Permeability and Hazardous Waste Storage," Journal Water Pollution Control Federation: 53(8), 1347, August 1981.

The soil mantle itself is an important attenuator of many types of hazardous constituents. The soil mantle through which a groundwater system flows can serve as a filter or adsorption bed and can support microorganisms that break down certain organic compounds. Soil also serves to minimize the mixing of contaminated and uncontaminated water. Thus geology, hydrology, soil and other conditions of a secured landfill site are central elements of a hazard definition.

Constituent Persistence and Bioaccumulation

Persistence addresses the tendency of hazardous constituents to remain in the environment unchanged for a given period of time. Persistence is a function both of waste attributes and environmental factors. Elements such as mercury and arsenic will persist in the environment in some form permanently under virtually any environmental scenario. Some organic compounds, such as toxaphene, hexachloroethane and carbon tetrachloride are also highly persistent.[1] Bioaccumulation concerns the tendency of a given constituent to accumulate in selected body tissues or organs of exposed organisms. Toxaphene, mercury and acrylonitrile are highly bioaccumulative compounds.[2]

Since the hazardousness of a given disposal scenario also hinges on the persistence of particular toxic or carcinogenic constituents, these issues should be addressed in a degree of hazard scheme as this factor determines the length of time a chemical must be isolated from the environment for public safety. Clearly a highly toxic constituent that biodegrades to an innocuous chemical form in a matter of hours does not pose the same hazard over time as one that persists in its toxic form for many years, although it may pose considerable hazard at the point of generation or during handling. Similarly a constituent such as mercury that becomes biomagnified, particularly in food organisms such as fish, demonstrates yet another dimension of hazard potential which should be considered in the evaluation of waste management scenarios which involve the potential for constituent migration to surface water bodies.

Realization of Hazard

The realization of hazard to public health or the environment requires that the receptor be exposed to the constituent at a concentration level and over a time period sufficient for the effect to be realized. Thus the proximity of receptor populations and of drinking water supplies are typical issues that are central determinants of hazard potential. The effects can include carcinogenicity, mutagenicity, teratogenicity, chronic and/or acute toxicity.

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[1] For example, toxaphene demonstrates a hydrolysis half-life of greater than 10 years at pH 5 to pH 8 and 25°C.

[2] For example, toxaphene, mercury and acrylonitrile have estimated bioconcentration factors of 76,000; 6200; and 110 respectively.

REPORT ORGANIZATION

This report is organized in six chapters. Chapter 2 describes the study approach to selecting case study waste streams for hazard classification and the method employed to choose particular degree of hazard schemes for application and evaluation. Chapter 3 describes and presents actual waste classifications according to the three classification approaches. In Chapter 4 the selected degree of hazard schemes and waste streams are described and compared. Chapter 5 presents the summary of results of the waste hazard assessment effort. Chapter 6 presents recommended approaches to the incorporation of the degree of hazard concept in national waste management policy. Three appendices are also provided. Appendix A contains background material pertaining to waste streams and constituent properties. Appendix B contains background material for the case study facilities. Appendix C includes classification score sheets.

CHAPTER 2

STUDY APPROACH

Engineering-Science's (ES) approach to the application and evaluation of degree of hazard schemes involved the following twelve basic tasks:

Task 1. Establish industry, process, and waste stream case study selection criteria;

Task 2. Conduct data availability survey regarding chemical and process data, toxicity data, and environmental fate and persistence data;

Task 3. Select case studies and waste categorization schemes;

Task 4. Conduct data search and synthesis;

Task 5. Characterize wastes and current disposal practices;

Task 6. Characterize toxicity, fate, environmental persistence, and bioaccumulation potential of waste stream components;

Task 7. Characterize site-specific or process-specific variables influencing environmental fate of waste stream components;

Task 8. Apply selected waste categorization schemes;

Task 9. Conduct comparative evaluation of waste categorization schemes;

Task 10. Identify and evaluate potential disposal options and identify associated costs.

Task 11. Identify priority considerations for nationwide application of categorization schemes; and

Task 12. Evaluate feasibility of incorporating the degree of hazard concept in a national waste management policy.

The design of selection criteria for waste streams and degree of hazard schemes, and the development of data to satisfy program requirements are discussed in the following sections.

DESIGN OF SELECTION CRITERIA AND SELECTION OF CASE STUDY WASTE STREAMS

A major goal of the degree of hazard classification program was to evaluate the various schemes' capacities to distinguish waste management situations with high hazard potential from those with low hazard potential. In light of this objective, the waste stream selection process involved identifying waste streams which could be characterized empirically as demonstrating either high or low hazard potential. Recognizing toxicity and volume as critical elements of hazardousness, ES identified waste streams expected to represent the following four categories to ensure that the ends of the spectrum of hazardousness were covered in the case study sample:

- High volume/high toxicity;
- High volume/low toxicity;
- Low volume/high toxicity; and
- Low volume/low toxicity.

Determination of High vs. Low Volume

Engineering-Science reviewed the available EPA hazardous waste listing background documents prepared under RCRA Section 3001. These documents provide summary descriptions of selected industrial operations and characteristic waste streams. Included in many of these industry summaries are annual industry-wide waste generation estimates. In those cases where fewer than 10-15 plants produce a given waste stream, facility-by-facility estimates of annual waste generation are often presented. ES ranked selected waste streams by annual volume generated on an industry-wide basis and adapted the following general guidelines for characterizing wastes as either high or low volume:

High volume > 250,000 tons/year
Low volume < 5,000 tons
Medium volume 5,000 tons to 250,000 tons/year

These guidelines were employed in the selection of the case study waste streams.

Later in the study it became apparent that the facility-by-facility waste volume generated constitutes the actual link between hazard potential and waste volume; not the volume generated nationwide. That is, the degree of hazard schemes are applied on a facility-by-facility basis and factor waste quantity into the degree of hazard determination. Thus the original characterization of high and low volume for each waste stream was subsequently revised on a facility-by-facility basis in conjunction with scheme application as discussed in Chapter 3.

Consideration of Toxicity in Waste Stream Selection

The extant data base by which scientists evaluate the relative toxicity of chemical substances is often characterized as incomplete and of uneven quality. Of those data required for the application of degree of hazard schemes, the toxicity data were anticipated to be the least complete data set for any given set of substances. The project team maintained that the hazard classification methods could be most effectively evaluated if waste streams were selected for which reasonably complete data sets exist. Thus, availability of toxicity/ carcinogenicity data served as a preliminary criterion for selecting case study waste constituents.

Engineering-Science conducted a data availability search on chemical constituents using the National Institute of Occupational Safety and Health (NIOSH) Registry of Toxic Effects of Chemical Substances (RTECS) accessible through the National Library of Medicine. Once the comparatively well-studied waste constituents were identified, ES ranked them in terms of their relative toxicity according to carcinogenicity and oral rat LD_{50} (i.e., lethal dose, 50 percent kill). This ranking served as a general guideline for characterizing waste streams as highly toxic or not highly toxic. These guidelines were only intended for purposes of waste stream selection. They were not intended to represent degree of hazard assessment criteria.

The high and low toxicity characteristics were generally assigned as follows:

Highly toxic = carcinogenic and/or Oral Rat LD_{50} <400 mg/kg;
Low toxicity = non carcinogenic and/or Oral Rat LD_{50} >15000 mg/kg.[1]

Other Waste Stream Selection Criteria

After identifying a series of candidate waste streams from the four volume and toxicity-based categories for which adequate data exist, the project team evaluated the suitability of these wastes for consideration in the study based on additional selection criteria. The objective of this effort was to enable selection of a diverse sample relative to the following variables:

1. Number of toxic constituents in the waste stream (one vs. multiple);
2. Number of EPA-defined hazardous characteristics in the waste stream (toxic only vs. toxic and ignitable, corrosive or reactive);
3. Representation of the spectrum of several hazard characteristics in the study sample (highly persistent substances vs. non-persistent substances; carcinogenic substances vs non-carcinogenic toxic substances);
4. Potential for treatment/disposal by technologies other than landfilling (e.g. incineration);
5. Concentration of a specific toxic constituent in two or more waste streams (high concentration vs. low concentration);
6. Degree of standardization of industrial processes and waste component ratios (standardized vs. variable processes); and
7. Representation of organic vs. inorganic toxic constituents.

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[1] These general guidelines were adapted from assertions put forth by Dr. N. Irving Sax in Dangerous Properties of Industrial Materials, fifth edition, Van Nostand Reinhold Company, New York, p. vii, 1979.

The approach to waste stream selection relied on the assumptions that: (1) Wastes listed or proposed for listing by EPA comprise the sample for which process variables and toxicity/environmental fate issues had been most widely studied and for which data were most centralized; and (2) The NIOSH RTECS data base represents a reasonable state-of-the-art data compilation of toxicity information, organized by substance.[1] ES used these information sources in the preliminary waste stream selection process because they seemed suitable to the task of concentrating on scheme evaluations rather than data collection.

Over 50 waste streams were considered for inclusion in the study; from those, nine were selected. Empirically, the nine preliminary waste streams selected were grouped into hazard categories as follows:

High Volume/Low Toxicity

- Wastewater treatment sludge from the production of titanium dioxide (TiO_2) pigment using chromium-bearing ores by the chloride process. (Delisted by EPA as of October 1980 this waste exemplifies a waste of low hazard potential by EPA criteria.) (K074)

High Volume/High Toxicity

- Bottom stream from the acetonitrile column in the production of acrylonitrile. (K013)

Medium Volume/High Toxicity

- Brine purification muds from the mercury cell process in chlorine production where separately prepurified brine was not used. (K071)

Low Volume/Low Toxicity

- Light and heavy ends from the distillation of acetaldehyde in the production of acetic anhydride. (Not listed by EPA.)

Low Volume/High Toxicity

- Chlorinated hydrocarbon wastes from the purification step of the diaphragm cell process using graphite anodes in chlorine production. (K073)
- Wastewater treatment sludge from the production of toxaphene. (K041)
- Distillation bottoms from the production of nitrobenzene by the nitration of benzene. (K025)

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[1] A sometimes significant margin of error is characteristic of all massive toxicological data compendia. RTECS is no exception. However, the objective of the Degree of Hazard Program was to evaluate schemes, not data reliability.

- Ammonia still lime sludge from coking. (K060)
- Spent stripping and cleaning bath solutions from electroplating operations where cyanides are used in the process (except for precious metals electroplating spent stripping and cleaning bath solutions). (F009)

ES selected these waste streams because they represent the four primary hazard categories and they also are diverse in terms of persistence of toxic constituents, number of toxic constituents, hazard characteristics other than toxicity and carcinogenicity, and include organic and inorganic toxic constituents. For example, of the streams selected in the low volume/high toxicity category, toxaphene wastes contain one toxic constituent which is extremely toxic (oral-rat LD_{50}:40 mg/kg), carcinogenic, mutagenic and teratogenic. By contrast, the chlorinated hydrocarbon waste in this category contains multiple toxic constituents, these constituents are less toxic (oral-rat LD_{50}'s in the 250-10,000 mg/kg range) than toxaphene but several are also known carcinogens, mutagens and teratogens. The project team was interested to see if the degree of hazard schemes would distinguish such differences.

ASSESSMENT AND SELECTION OF CATEGORIZATION SCHEMES

ES studied the existing waste classification schemes in the literature and prepared tables outlining the data requirements of the following seven selected schemes:

1. State of Washington Waste Classification Scheme;[1]
2. State of Rhode Island Waste Classification Scheme;[2]
3. Michigan Rank-Order Assessment of Critical Materials;[3]
4. JRB Environmental Containment Waste Characterization Scheme;[4]

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[1] Washington State Department of Ecology, Chapter 173-302, Washington Administrative Code Hazardous Waste Regulation, Seattle, WA, 1978.

[2] Rhode Island Hazardous Waste Management Facility Operating Permit Rules and Regulations-Landfills, September 1979, amended November 1980. Available through State of Rhode Island, Department of Environmental Management, Division of Air and Hazardous Materials, Providence, RI.

[3] Michigan Department of Natural Resources, Draft Hazardous Waste Regulation, Lansing, MI, June 11, 1980.

[4] JRB Associates. Methodology for Rating the Hazard Potential of Waste Disposal Sites, McLean, VA, 1980.

5. State of California Waste Classification Scheme;[1]
6. State of Texas Waste Classification Scheme;[2] and
7. Chemical Manufacturers Association Waste Classification Scheme.[3]

The salient attributes of each scheme were summarized and approaches were compared. For each scheme, data requirements unique to that scheme were identified and any required methods of measuring the variables were noted. Table 2 summarizes the data requirements of the schemes.

Toxicity is considered by all classification schemes although the specified means for measuring toxicity varies among schemes. Corrosivity is also considered by all classification schemes and the designated measure of corrosivity also varies among schemes.

Application of the JRB scheme also involves the investigation of the following site-specific and waste management variables not required for the other six candidate schemes. (It should be noted that the JRB Scheme was developed as a tool to set remedial action priorities, not to establish a degree of hazard classification methodology.)

WASTE MANAGEMENT PRACTICES

Site security
Total waste quantity
Waste incompatability
Use of liners
Use of leachate collection systems
Use of gas collection systems
Use and condition of containers

RECEPTORS

Population within 1,000 feet
Distance to nearest drinking water well
Distance to nearest off-site building
Land use/zoning
Critical environments

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[1] California Assessment Manual for Hazardous Waste. Criteria for Identification of Hazardous and Extremely Hazardous Waste, Title 22, California Administrative Code, Division of Environmental Health, Chapter 30, Minimum Standards for Management of Hazardous and Extremely Hazardous Waste, 27 March 1981. Available through California Department of Health Services, Hazardous Materials Management Section, Sacramento, CA.

[2] Texas Solid Waste Disposal Act, Article 4477-7, Texas Civil Statutes (1975). Available through Texas Department of Water Resources, P.O. Box 13087, Capitol Station, Austin TX, 78711.

[3] Chemical Manufacturers Association, A System for Management of Hazardous Wastes by Degree of Hazard under Subtitle C of RCRA, Washington, D.C. 1980.

TABLE 2

DATA REQUIRED FOR DEGREE OF HAZARD WASTE CLASSIFICATION SCHEMES

Hazard Characteristic	Candidate Degree of Hazard Classification Schemes						
	Washington	Rhode Island	Michigan	JRB	California	Texas	CMA
Toxicity	X	X	X	X	X	X	X
Persistence	X	X	X	X	X		X
Carcinogenicity	X	X	X		X		
Mutagenicity			X				X
Teratogenicity			X				
Bioaccumulation Potential			X		X		X
Irritation		X	X		X	X	
Infectiousness	X	X	X		X[1]		X
Sensitization		X	X		X	X	
Radioactivity		X		X	X[1]		X
Corrosivity	X	X	X	X	X	X	X
Reactivity	X	X	X	X	X		X
Ignitability/ Flammability	X	X	X	X	X	X	X
Explosiveness	X		X				
Solubility				X			
Volatility				X			
Physical State				X			
Waste Quantity	X		X	X			

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[1] Covered by other California regulations.

PATHWAYS

- Evidence of contamination
- Type of contamination
- Distance to nearest surface water
- Depth of groundwater
- Net precipitation
- Soil permeability
- Bedrock permeability
- Depth of bedrock

Rationale for Recommended Exclusion of Particular Waste Classification Schemes

In the recently issued technical memorandum, the U.S. Congress Office of Technology Assessment identified specific types of degree of hazard approaches, including "classification using technical criteria", (single criteria-based schemes).[1] The project team sought to include one of each of these schemes in the study as well as a scheme that addressed environmental site suitability.

ES considered the classification schemes characterized by the Office of Technology Assessment as "based on technical criteria". Five of the seven schemes fall into this category: CMA, Washington, Rhode Island, California, and Texas. A preliminary assessment suggested that the Washington and Rhode Island methods provide the most comprehensive coverage of hazard variables. Specifically, both these schemes consider a variety of hazard characteristics in addition to toxicity, and associate certain disposal criteria with hazard classification. The required consideration of the concentration of toxic constituents in wastes by Washington led ES to recommend Washington's scheme as most suitable for application to diverse wastes. The project team observed less universal applicability and a lack of management differentiation in the other two state schemes, and thus eliminated the Texas and California schemes from consideration.

Application of the CMA Waste Classification Scheme posed a problem. The scheme relies on toxicity and other data obtained from tests on extracts of each specific waste evaluated, rather than standardized data on the toxic constituents in the waste. While ES considered this approach more realistic and possibly more defensible scientifically than the constituent approach, it seemed unlikely that the requisite data for waste extracts from the desired variety of waste streams would be available, as was indeed the case. Thus ES also eliminated this scheme from consideration.

SCHEME SELECTION

ES selected the following waste classification schemes for application to the sample of industrial waste streams:

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[1] Congress of the United States, Office of Technology Assessment "Nonnuclear Industrial Hazardous Waste: Classifying for Hazard Management," A Technical Memorandum, Washington, D.C., November 1981.

1. JRB Environmental Containment Waste Characterization Scheme: This scheme is applicable only on a site-specific basis. The rationale for endorsing this approach involved not only the concern that waste disposal safety is a site-sensitive concept but also the fact that this approach addresses the frequently-expressed criticism regarding the non site-specific nature of most degree of hazard schemes.

2. State of Washington Waste Classification Scheme: This scheme was recommended for study because it represents a unique approach to developing hazard evaluations for wastes containing multiple toxic constituents. This scheme is a technical criteria scheme.

3. Michigan Rank-Order Assessment of Critical Materials: This scheme was recommended because it represents a relatively well-developed and logical rank-order approach to hazard asessment involving the consideration not only of toxicity and carcinogenicity but also such factors as constituent persistence and bioaccumulation potential.

The Michigan and Washington Schemes have the following elements in common:

- They provide management designations which prequalify facilities for regulation.
- They employ toxicity rating methods based not on waste stream properties, but on toxic constituent properties.
- They provide specific standards and criteria for evaluation.
- They consider waste quantity in management categorization.
- They consider constituent concentration in management categorization.
- They do not involve an evaluation of environmental suitability in facility management category designation.

DATA GATHERING

Once the case study waste streams and classification schemes were established, ES gathered from the toxicological and physical/chemical literature all available data required to apply the schemes. A summary of salient characteristics of waste stream constituents is provided in Table 3, Summary of Physical, Chemical, and Toxicological Characteristics of Constituents of Case Study Wastes. To supplement these data and to collect information not available in the literature, the study team then conducted a series of telephone interviews with industry representatives. Over 30 representatives of industrial facilities generating and disposing the case study waste streams were contacted by phone and by mail. ES interviewed those industry contacts who were willing to participate in the study and whose industrial process did in fact result in the generation of the case study waste streams.

The purpose of the industry interviews was to (1) profile the quantities of waste generated at particular facilities and the concentrations

TABLE 3

SUMMARY OF PHYSICAL, CHEMICAL AND TOXICITY CHARACTERISTICS OF CONSTITUENTS OF CASE STUDY WASTES

	Constituent	Rat Acute Toxicity (mg/kg)	Carcino-genicity	Muta-genicity	Terato-genicity	EPA Estimated Bio-concentration Factor	Persis-tence	Log P	Vola-tility	Solu-bility
KO71	Mercury	-	-	-	+	6,200	High	-	Low	-
	Cyanide	-	-	-	-	2.3	Yes	-	Low	High
	Naphthalene	1,780		-	-	60	Yes	3.36	Low	Low
KO60	Phenolics	414		+		2.3	Low	-2.2	Low	Low
	Arsenic pentoxide	8	+	+	+	2.3	Yes	0	Low	High
	Arsenic trioxide	20	+	-	-	2.3	Yes	0	Low	High
	Potassium cyanide	10	-	+	-	-	Yes	-	Low	High
FO09	Sodium cyanide	6.44	-	-	-	-	No	-	Low	High
	Acetonitrile	3,800	-	-	+	-	-	- .34	High	High
KO13	Acrylonitrile	82		+	+	110	-	- .34	High	High
	Hydrocyanic acid	10	-	-	-	-	-	-.35 -.38	High	High
Light	Methyl acetate	4,800	-	-	-	-	-	.25 -.33	High	Low
&	Acetone	9,750	-	-	-	-	-	.29 -.88	High	High
Heavy	Ethylidene diacetate	3,730	-	-	-	-	-	-	Low	
Ends*	Ethyl acetate	11,000	-	-	-	-	-	.66 -.73	Med	Low
	Hexachloroethane	6,000	+	-	-	-	High	3.34	Slight	Slight
	Trichloroethane (1,1,1)	10,300	-		-	-	-	2.17	Med	Med.
KO73	Trichloroethane (1,1,2)	1,140	+	-	+	6.3	High	2.49	Med	Slight
	Dichloroethylene (1,1)	250	+	+	-	-	-	-	High	Med
	Dichloroethylene (1,2)	770	-	+	-	-	-	-	High	Med
	Chloroform	800	+	-	+	6	High	1.95	Med	Slight
	Carbon tetrachloride	2,800	+	-		30	High	2.64	Med	Med
	Tetrachloroethylene	8,100	+	-	-	-	Yes	2.88	Low	Low
	1,1,2,2-tetrachloroethane	42,000	+	-	-	-	-	2.59	Low	Med
KO41	Toxaphene	40	+	+	+	76,000	High	2.92	Low	Low
KO25	Meta-dinitrobenzene	30	-	+	-	-	Yes	1.49-1.56	Low	Low
	2,4-dinitrotoluene	268	+	+	-	-	Yes	1.49-1.56	Low	Low
KO74	Hexavalent chromium	-	+	+	-	-	+	0	-	High
	Trivalent chromium	1,870	-	-	-	-	-	-	-	Low

* Light and heavy ends from the distillation of

of toxic constituents in those waste streams, (2) develop the site-specific information required to conduct the JRB Environmental Containment Waste Characterization Scheme, and (3) to summarize the waste management practices undertaken by the individual facilities prior to RCRA, presently in effect, and planned for the future. The basic issues addressed during these discussions are summarized in Table 4, Industrial Facility Profile Information Requirements.

These data gathering efforts provided the information required to conduct the waste classifications and evaluations presented in this report.

STUDY APPLICATIONS

Once the available data were assembled, the project team applied the three selected degree of hazard schemes to the wastes. Upon comparing the results of the various hazard assessment procedures the team considered the potential benefits and limitations of the degree of hazard concept in terms of several broad policy considerations. Among the policy issues of concern to degree of hazard implementation are the following:

- What are the benefits and limitations of employing a degree of hazard classification from the perspective of industry and society?
- What are the general economic implications of implementing a degree of hazard approach to hazardous waste management?
- What limitations characterize the existing data base in terms of degree of hazard scheme applications?
- How might the existing data bases and waste generation information be improved to facilitate and strengthen degree of hazard assessment?
- What types of characteristics make different classes of waste streams or industrial facilities amenable to degree of hazard classification?
- For which types of industries does degree of hazard assessment suggest the most improvement in terms of waste management cost/benefit ratios?
- What are the prominent regulatory and other institutional obstacles to degree of hazard implementation?

These issues are discussed in Chapters 5 and 6.

TABLE 4

INDUSTRIAL FACILITY PROFILE INFORMATION REQUIREMENTS

1. EPA waste generator identification number.
2. EPA waste stream identification codes for generated wastes.
3. Name, address, and phone of facility and facility representative.
4. Amount of case study waste generated.
5. Description of treatment, storage and disposal practices for case study wastes.
6. Other wastes undergoing same treatment, storage and disposal practices.
7. Toxic constituents present in waste stream.
8. Average and range of constituent concentrations in case study waste stream.
9. Waste pH.
10. Waste flash point.
11. Description of waste variability relative to constituent concentrations and daily volume.
12. Handling practice variability.
13. Waste management practice changes implemented subsequent to effective date of RCRA (11/19/80).
14. Anticipated changes in waste management practices.
15. Comparative waste management costs prior to and subsequent to implementation of RCRA.
16. Environmental controls practiced in conjunction with waste management activities.
17. Specific waste management features:
    - site security provisions
    - waste incompatibilities
    - use of leachate collection system
    - use of gas collection system
    - use and condition of containers.
18. Specific site features:
    - population within 1,000 feet
    - distance to nearest drinking water well
    - distance to nearest off-site building
    - land use/zoning
    - critical environments in facility vicinity
    - evidence of contamination on-site
    - type of contamination
    - distance to nearest surface water
    - depth to groundwater
    - net annual precipitation
    - soil permeability
    - bedrock permeability
    - depth to bedrock.
19. Other comments.

CHAPTER 3

SAMPLE DEGREE OF HAZARD DETERMINATIONS

This Chapter provides sample degree of hazard classifications according to each of the three hazard schemes for one case study waste stream, "Distillation Bottoms from the Production of Nitrobenzene by the Nitration of Benzene" (EPA Hazardous Waste Identification Number K025). The purpose of this presentation is to demonstrate the mechanics of the schemes' approaches to hazard assessment and to illustrate typical problems inherent in degree of hazard determination. The classifications for the entire case study sample are summarized in Chapter 4.

CASE STUDY WASTE STREAM

General Description

Nitrobenzene is principally used in the production of aniline dyes. Distillation bottoms from nitrobenzene production were listed by EPA because of their toxicity. They contain toxic, mutagenic and carcinogenic organic substances. A low volume, highly toxic waste, distillation bottoms are reportedly generated by seven plants at a combined annual rate of 500 tons[1].

The constituents of concern in the listing of this waste are meta-dinitrobenzene and 2,4-dinitrotoluene. Tables 5 and 6 summarize various physical, chemical, and toxicological properties of these constituents. The parenthetical numbers on the tables refer to the corresponding references as presented on Page 20. The top sections of these tables describe various constituent aspects which relate to their toxicity. Included in this array of variables is a column labeled Sax Rating. The Sax Rating refers to the toxicity hazard rating assigned to the constituent as reported by Dr. N. Irving Sax in Dangerous Properties of Industrial Materials (fifth edition). Although this reference was prepared to address industrial hygiene, the data and principles applied in the derivation of the toxicity ratings are applicable to relative toxicity assessment. The various toxicity categories comprising this scale are defined as follows:

NONE - No harm via exposures of normal use; harmful only due to overwhelming dose or unusual conditions (LD_{50} greater than 15,000 mg/kg);

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[1] U.S.EPA, Office of Solid Waste, Background Document, Resource Conservation and Recovery Act, Subtitle C-Identification and Listing of Hazardous Wastes, (Phase 1B) 7 July 1980.

TABLE 5

TOXICITY AND PHYSICAL CHARACTERISTICS OF META-DINITROBENZENE

(WASTE: K025 - Distillation bottoms from the production of nitrobenzene by the nitration of benzene)

TOXICITY

ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONISTIC EFFECTS
Rat LD_{50} 30 mg/kg (1) Bird (wild) LD_{50} 42 mg/kg (1) (10)	Lethal concs. minnows: 10-12 mg/l (distilled H_2O) Fish: 2 mg/l (all unspecified isomers of dinitrobenzene) (2)	Man TDLo 4 mg/kg (1)	Most potent methemoglobin-forming agent of the nitroaromatics (2)	No data (2)	Bacteria positive (1) Positive for dinitrobenzene metabolite dinitrophenol; no data on dinitrobenzene (2)	Sea urchin positive for dinitrophenol; no effects on animal; no data on dinitrobenzene (2)	Low bioconc. potential (2)	HIGH via oral (10)	Symptoms potentiated by exposure to sunligh or ingestion of alcohol (2)

PHYSICAL

NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
Health* 2 3 Flamm: 1 React: 3 (9) [*two different values were quoted in one source]	(2,5-) (Moderately persistent: persistence in unadapted soil: 3-18 months - Cat 4) (4) Relatively stable at ambient temperatures (2)		Insoluble (5) .03 pph @ 22°C (8) 270 mg/l @ 22°C (2)			404°F (9) 404°F (10)

TABLE 6

TOXICITY AND PHYSICAL CHARACTERISTICS OF 2,4,-DINITROTOLUENE

(WASTE: K025 - Distillation bottoms from the production of nitrobenzene by the nitration of benzene)

TOXICITY

ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONISTIC EFFECTS
Rat LD$_{50}$ 268 mg/kg (1) (10) Rat LD$_{50}$ 707 mg/kg (7)	TLm96: 100 - 10 ppm (1) TLm96: fathead minnow: 31 mg/l (2)		Human, animals: liver damage, jaundice, methemoglobinemia, reversible anemia with reticulocytosis (2) Irritant, allergen (10)	Animal positive (1) (2)	Bacteria, animal positive (2)	No data (2)	Est. wt avg bioconc. factor for edible portions of fish & shellfish consumed by Americans: 5.5 (2) 19 (2)	HIGH via oral, inhal dermal	Alcohol has synergistic effect on toxicity (2)

PHYSICAL

NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
Health* 2 3 Flamm: 1 React: 3 (9) [*two different values were quoted in one source]	(2,6-) (Moderately persistent: persistence in unadapted soil: 3-18 months - Cat 4) (4) Relatively stable at ambient temperatures (2)		Insoluble (5) .03 pph @ 22°C (8) 270 mg/l @ 22°C (2)			404°F (9) 404°F (10)

LIST OF REFERENCES FOR TABLES 5 and 6

1. National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, Registry of Toxic Effects of Chemical Substances, U. S. Government Printing Office, Washington, D. C., 1980.

2. USEPA, Office of Solid Waste, Background Document, Resource Conservation and Recovery Act, Subtitle C - Identification and Listing of Hazardous Wastes, Appendix A: Health and Environmental Effects, Washington, D.C., May 1980.

3. USEPA, Office of Solid Waste, Background Document, Resource Conservation and Recovery Act, Subtitle C - Identification and Listing of Hazardous Wastes, Appendix B: Fate and Transport of Hazardous Constituents, Washington, D.C., May 1980.

4. Abrams, E. F. et.al., Identification of Organic Compounds in Effluents from Industrial Sources, National Technical Information Service, U.S. Department of Commerce, Washington, D.C., 1975.

5. Weast, Robert C., Samuel Selby, and Charles Hodgman, editors. Handbook of Chemistry and Physics, Forty-fifth edition. The Chemical Rubber Company, Cleveland, OH, 1964.

6. USEPA, Office of Solid Waste, Background Document, Resource Conservation and Recovery Act, Subtitle C - Identification and Listing of Hazardous Wastes (Phase 1B), Washington, D.C., August 1979.

7. USEPA, Office of Solid Waste, Background Document, Resource Conservation and Recovery Act, Subtitle C - Hazardous Waste Management, Section 3001-Identification and Listing of Hazardous Waste. Section 261.33-Hazardous Waste from Discarding of Commercial Chemical Products and the Containers and Spill Residues Thereof, Washington, D. C., 30 April 1980.

8. Perry, Robert H., and Cecil Chilton, Chemical Engineers' Handbook, Fifth Edition, McGraw Hill, NY, 1973.

9. National Fire Protection Association (NFPA), Fire Protection Guide on Hazardous Materials, 7th Edition, Boston, MA, 1978.

10. Sax, Irving, Dangerous Properties of Industrial Materials: Fifth Edition, Van Nostrand Reinhold Company, New York, 1979.

11. Mackison, et. al. (editors), NIOSH/OSHA Pocket Guide to Chemical Hazards, U.S. Department of Health and Human Services, Government Printing Office, Washington, D.C., August 1980.

12. Michigan Department of Natural Resources, Environmental Protection Bureau, Environmental Services Division, Critical Materials Register Data Base, Lansing, Michigan.

LOW = Causes readily reversible tissue changes which disappear after exposure stops; causes some discomfort (LD_{50} of 7,500 mg/kg to 15,000 mg/kg);

MOD = May cause reversible or irreversible changes to exposed tissue, not permanent injury or death; can cause considerable discomfort (LD_{50} of 500-7,500 mg/kg);

HIGH = Capable of causing death or permanent injury due to the exposures of normal use; incapacitating and poisonous; requires special handling (LD_{50} of 500 mg/kg or less); and

UNKNOWN = Insufficient data or experience recorded or available to permit a statement.

As is evident from Tables 5 and 6, results of toxicity tests indicate that these constituents are both highly toxic. Tests also suggest that these chemicals are either carcinogenic or mutagenic. Both chemicals received a high Sax rating for toxicity.

The second set of criteria presented on Tables 5 and 6 relate to the physical properties of the waste constituents. The column labeled NFPA rating relates to the National Fire Protection Associations numerical system of rating hazards in three categories: health, fire and reactivity. The rating scale ranges from "0" (nonhazardous) to "4" (extremely hazardous). As is evident from the table, the constituents receive ratings of "3" and "4" for reactivity. The reactivity rating must be interpreted with caution, however, because the reactivity hazard should be evaluated for the entire waste stream, not simply for individual constituents. As noted on the tables, these two constituents will persist in the environment.

Facility Profile

The conduct of the degree of hazard assessments requires the use of data concerning the quantity of waste generated and the concentration of constituents of concern on a facility-by-facility basis. Table 7 presents a brief profile of one facility (K025.1) that generates and disposes waste K025. The facility described in Table 7 incinerates a waste, which not only contains the two constituents addressed in the EPA Background Listing Background Document but also contains three other toxic constituents which are considered in the degree of hazard classifications. These constituents are benzene, nitrobenzene, and aniline.

TABLE 7

INDUSTRIAL FACILITY PROFILE

1. Waste stream: K025
   Distillation bottoms from the production of nitrobenzene by the nitration of benzene.

2. Facility code: K025.1

3. Quantity generated: 16,500 pounds annually

4. Concentration of constituents of concern:

meta-Dinitrobenzene:	0.1-0.2%
2,4-Dinitrotoluene:	<0.01%

Other constituents:

Benzene:	0.01%
Nitrobenzene:	96-98%
Aniline:	1-1.5%

5. Waste pH when mixed with equal weight of H_2O: 8-9

6. Flash point: 88°C

7. Radioactivity: N/A

8. Management procedures for case study waste:

Basic Management Steps

   a. Wastes are stored in tanks prior to disposal
   b. Wastes are incinerated. Greater than 99% destruction and removal efficiency.

9. Waste management history: wastes have been incinerated for the past 10-15 years.

10. Anticipated waste management procedures: the facility managers anticipate no changes in waste management practices.

DEGREE OF HAZARD CLASSIFICATIONS

State of Washington

The State of Washington Department of Ecology degree of hazard scheme is one component of an overall state waste characterization process for determining levels of waste management. This hazard assessment does not lead to the development of the graded hazard scale by which one could rank a series of waste streams. It does identify five related toxicity categories which factor into a consideration of waste quantity and toxic constituent concentration. The summary relationship between these three variables (toxicity, quantity, concentration) determines the waste designation for management purposes. This system classifies wastes into one of the following three management categories:

1. Non-dangerous wastes;
2. Dangerous wastes; or
3. Extremely hazardous wastes.

The extremely hazardous waste category is actually a subset of the dangerous waste category. For a waste to be designated as extremely hazardous, it must be first designated as dangerous. The degree of hazard scheme is then applied to determine which of the dangerous wastes can be further categorized in terms of the more restrictive extremely hazardous waste category. This section focuses on the application of the Washington degree of hazard scheme whereby waste are classified as either dangerous or extremely hazardous using K025 as an example waste stream. The overall waste characterization process as conceived and applied by the State of Washington is discussed in Chapter 5.

Basis of Scheme

The Washington degree of hazard scheme is based on the following waste stream characteristics:

- Toxicity of waste constituents;
- Persistence of waste stream constituents as defined by the presence of polycyclic aromatic hydrocarbons and halogenated hydrocarbons;
- Carcinogenicity of waste stream constituents;
- Quantity of waste generated; and
- Concentration of toxic, persistent and carcinogenic waste stream constituents.

The sequential evaluation of these waste characteristics according to a set of established standards and criteria on a facility-by-facility basis leads to the waste designation as demonstrated in the following example for K025.

Step 1: Identification of toxic constituents and constituent concentrations

The first step in the conduct of the Washington degree of hazard scheme involves the identification of the toxic constituents present in a waste stream and the determination of the concentrations. A representative of the case study facility generating and disposing K025 (designated by facility code K025.1) identified the following waste stream constituents as being present in the waste in the following concentrations:

K025.1 Constituent	Concentration (% by weight)
meta-Dinitrobenzene	0.1 - 0.2
2,4-Dinitrotoluene	<0.01
Benzene	0.01
Nitrobenzene	96 - 98
Aniline	1 - 1.5

Step 2: Classification of toxicity of waste stream constituents

The Washington State Department of Ecology developed a rating scale for the classification of constituent toxicity based on data reported in the literature. This toxicity classification scheme defines five categories according to the criteria presented in Table 8.

TABLE 8

STATE OF WASHINGTON DEPARTMENT OF ECOLOGY
CONSTITUENT TOXICITY EVALUATION CRITERIA

Category	Aquatic (Fish) LC_{50} (ppm)	Oral (Rat) LD_{50} (mg/kg)	Inhalation (Rat) LC_{50} (mg/l)	Dermal (Rabbit) LD_{50} (mg/kg)
X	<.1	<.5	<.2	<2
A	.1 - 1	.5 - 5	.02 - .2	2 - 20
B	1 - 10	5 - 50	.2 - 2	20 - 200
C	10 - 100	50 - 500	2 - 20	200 - 2000
D	100 - 1000	500 - 5000	20 - 200	2000 - 20,000

Oral rat LD_{50} data are reported in the NIOSH RTECS data base for each of the toxic constituents present in the waste stream generated by facility K025.1. The only other pertinent data relative to the Washington classification method reported in RTECS are the following:

Dermal (Rabbit) LD_{50}: Aniline: 820 mg/kg

Inhalation (Rat) LD_{50}: Benzene: 10,000 ppm

The rat LD_{50} values reported in RTECS and the corresponding toxicity classifications are presented in Table 9. Chapter 173-303 of the Washington Administrative Code (7/12/81) provides a list of chemical products with their corresponding toxicity classifications. Table 9 also presents the toxicity classifications for constituents present in the facility K025.1 waste as specified in WAC 173-303.

TABLE 9

TOXICITY CLASSIFICATION EMPLOYING ORAL RAT LD_{50} DATA REPORTED IN RTECS

K025.1 Constituent	Reported Oral Rat LD_{50} (mg/kg)	Toxicity Classification According to RTECS Oral Rat LD_{50} Data	WAC 173-303 Classification
meta-Dinitrobenzene	30	B	Not classified
2,4-Dinitrotoluene	268	C	C
Benzene	3800	D	C
Nitrobenzene	640	D	C
Aniline	440	C	C

As is evident from Table 9, in the case of two waste constituents, benzene and nitrobenzene, the classifications based on RTECS reported LD_{50} values are not the same as those assigned by Washington State. One possible explanation for this inconsistency involves the need to consult additional references for data concerning the other toxicity measures included in the Washington toxicity ranking. Table 10 presents additional data reported in the literature for benzene and nitrobenzene and the corresponding toxicity classifications.

This example illustrates the importance of establishing a standardized data base for use in degree of hazard classification. The classifications based on these additional data further suggest that the Washington scheme requires classification according to the parameters which result in the most toxic toxicity rating although this is not explicitly stated in the Washington reference. In accordance with this theory we will use the more stringent toxicity categories presented in Table 9 for the rest of this analysis.

TABLE 10

TOXICITY CLASSIFICATION CONSIDERING OTHER AVAILABLE DATA

Constituent	Toxicity Test	Test Result	Corresponding Toxicity Classification
Benzene	Aquatic LC_{50}	20 - 22 ppm (bluegill)*	C
		386 ppm (mosquito fish)*	D
Nitrobenzene	Aquatic LC_{50}	42.6 ppm (bluegill)*	C

* As reported in USEPA RCRA Background Document, Identification and Listing of Hazardous Wastes, Appendix A: Health & Environmental Effects, 1980.

Step 3: Calculation of waste stream equivalent concentration of toxic constituents

The State of Washington developed a formula whereby the de facto combined toxicity of a series of constituents is estimated. This approach does not account for antagonistic effects of constituents, but does apply a relative weighting scheme whereby a summary toxicity value is assigned to a waste stream containing several constituents of varying relative toxicity. This summary value is called "equivalent concentration" and incorporates both relative toxicity and constituent concentration.

The following formula is applied to determine the equivalent concentration:

$$\text{Equivalent Concentration (\%)} = \Sigma X\% + \frac{\Sigma A\%}{10} + \frac{\Sigma B\%}{100} + \frac{\Sigma C\%}{1000} + \frac{\Sigma D\%}{10{,}000}$$

where Σ(X,A,B,C, or D)% is the sum of all the concentration percentages for a particular toxic category.

Based on the most stringent toxicity classifications as discussed in conjunction with Step 2 the degree of hazard application to the waste generated by facility K025.1, the case study waste contains the following waste concentrations for the designated toxicity categories:

K025.1 Constituent	Toxicity Classification	Concentration (% by weight)
meta-Dinitrobenzene	B	0.1 - 0.2
2,4 Dinitrotoluene	C	<0.01
Benzene	C	0.01
Nitrobenzene	C	96 - 98
Aniline	C	1.0 - 1.5

The equivalent concentration based on the higher estimates for constituent concentrations is:

$$\text{Equivalent Concentration (\%)} = 0.2/100 + (0.01 + 0.01 + 98 + 1.5)/1000$$

$$= .002 + .09952 = 0.10152$$

If the lower estimates were used in the equivalent concentration calculation the value would be calculated as follows:

$$\text{Equivalent Concentration (\%)} = 0.2/100 (0.01 + 0.01 + 96 + 1.0)/1000$$

$$= .002 + .9702 = 0.099$$

These equivalent concentration values, 0.099-0.10152, represent the range of the summary evaluation of the toxicity of the waste generated at Facility K025.1.

Step 4: Consideration of equivalent concentration and waste quantities in management category designation

The determination of a waste's designation as either extremely hazardous or as dangerous relies on the relationship between the waste quantity and equivalent concentration as represented by the graph in Figure 1. In the case of facility K025.1, the equivalent concentration value is 0.09-0.10 percent and the total weekly batch waste quantity as reported by the facility representative is 317 pounds. As plotted on Figure 1, this waste is classified according to the State of Washington degree of hazard assessment scheme as an extremely hazardous waste (EHW) for management purposes. The waste would be undesignated if generated at the same equivalent concentration but at less than 100 pounds per week. It would be characterized as dangerous rather than extremely hazardous if generated in the same quantity but at an equivalent concentration of about 0.04 percent.

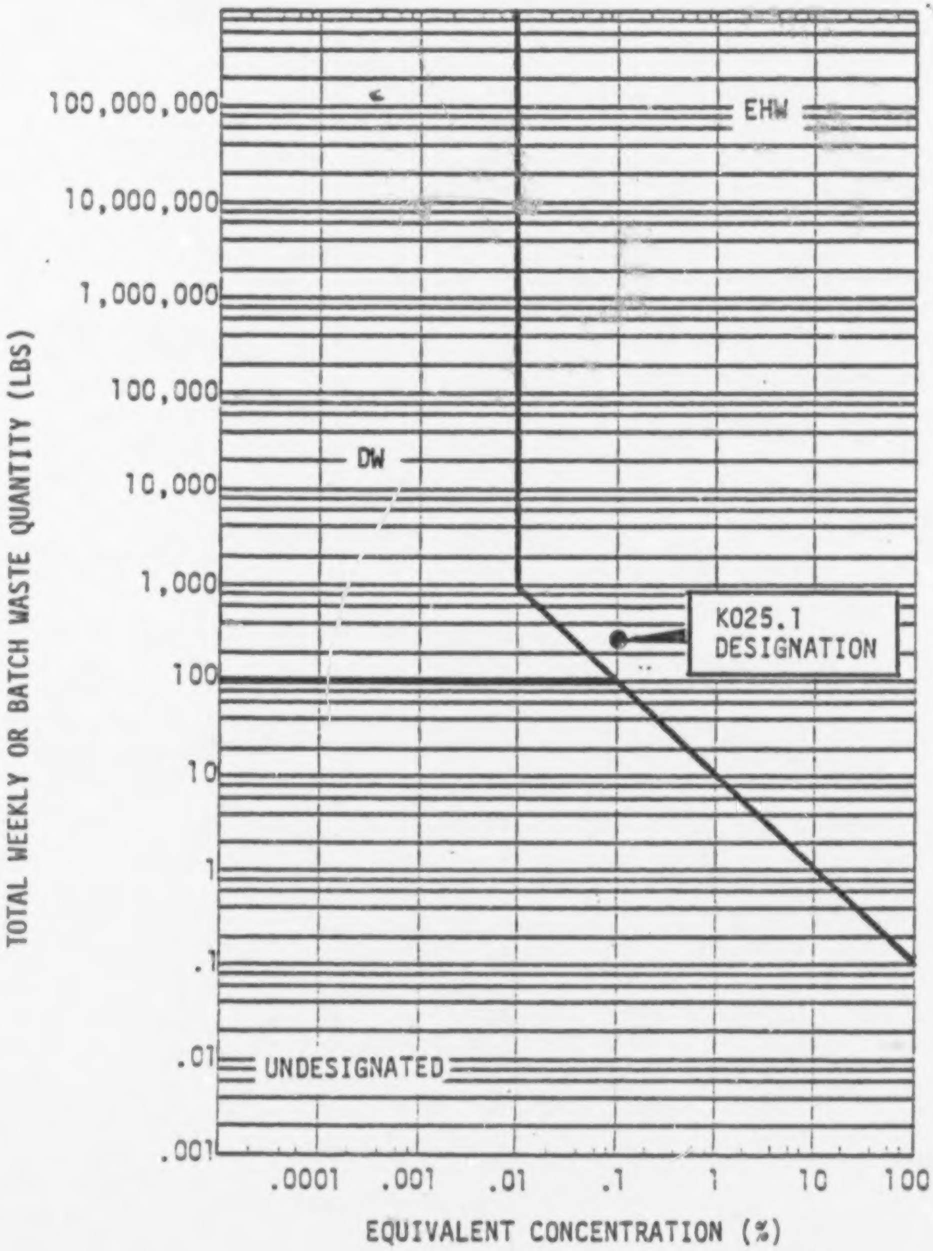
The EHW designation based on the actual quantity and equivalent concentration represents the last step required to classify the waste generated at facility K025.1. However had the waste not been designated as EHW, two other steps (consideration of persistence and of carcinogenicity) would be undertaken, as below.

Step 5: Consideration of waste stream persistence

The State of Washington degree of hazard scheme defines persistent wastes as those containing halogenated hydrocarbons (HH) and/or four-, five-, and six-ring polycylic aromatic hydrocarbons (PAH). The concentrations of these constituents may be determined by calculation if the concentrations of the significant persistent constituents are known and it can be demonstrated that any other persistent constituents whose concentrations are unknown are not a significant portion of the total

Designation of Facility K025.1 Waste
State of Washington

Degree of Hazard Assessment Scheme
Weekly Batch Quantity: 317 Pounds
Equivalent Concentration: 0.10



concentration. The calculation is a separate summation of the concentration percentages for halogenated or polynuclear aromatic hydrocarbons.

In the case of facility K025.1, no HH or PAH constituents are present in the waste stream. If they were present, their concentrations would be factored into the waste management designation in accordance with the quantity/concentration relationship depicted in Figure 2. As is evident from Figure 2 a quantity exclusion limit of 45.5 kg (100 lbs) is applied to the designation of these wastes.

Step 6: Consideration of carcinogenicity

In order to be classified as a carcinogenic substance the waste constituent(s) must meet the following criteria:

1. The constituent must be listed as an IARC (International Agency for Research on Cancer) human or animal, positive or suspected carcinogen.

2. If the constituent is listed as an inorganic, respiratory carcinogen, it must occur in a form which crumbles easily to form an inhalable dust.

The waste is considered a carcinogenic dangerous waste if the total concentrations of carcinogens are greater than 1.0 percent of the total waste, and the total weekly or batch quantity of waste produced is greater than 45.5 kg (100 lbs).

In the case of the waste generated by Facility K025.1, the following constituents are listed by the IARC as carcinogenic:

- 2,4-dinitrotoluene
- Benzene.

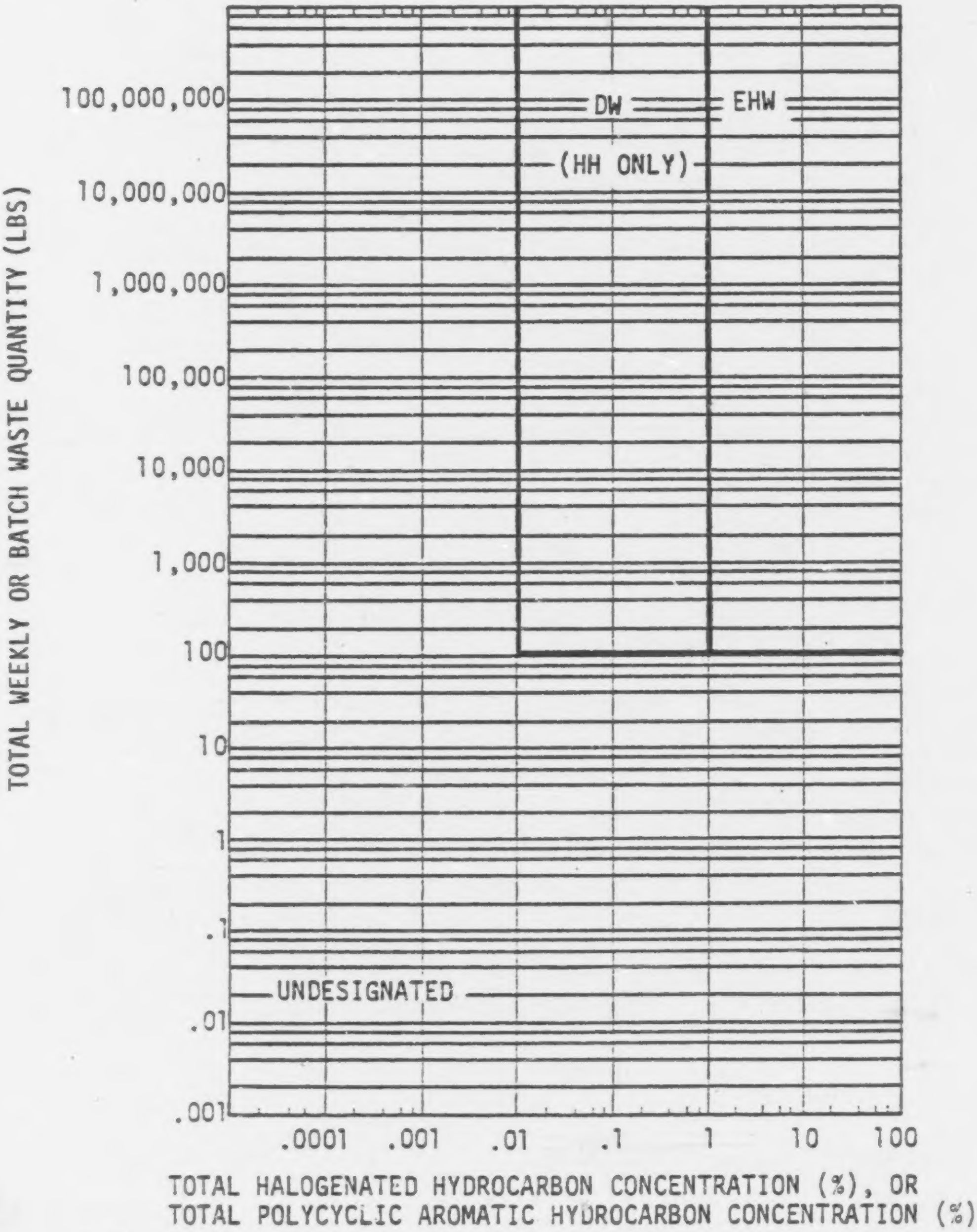
The combined concentration of these constituents in the waste stream equals about 0.02 percent. Because the waste has already been classified for management in the extremely hazardous waste category, the consideration of carcinogenicity in this case would not change the management designation.

Consideration of Handling Hazards

The degree of hazard approach in the context of the Washington scheme is used to distinguish between dangerous wastes and extremely hazardous wastes on the basis of potential long range hazards and principally in the context of land disposal. The consideration of handling hazards (i.e. ignitability, corrosivity, reactivity) is not a part of this procedure. These considerations are addressed by the overall waste classification scheme and not by the degree of hazard component. No waste, under the Washington scheme, can be designated as extremely hazardous on the basis of its potential handling hazards. Characteristic corrosivity, reactivity, and ignitability provide grounds

FIGURE 2

Persistent Dangerous Waste Mixtures Graph
State of Washington
Degree of Hazard Assessment Scheme



only for waste classification as dangerous. Thus the classification system makes no distinction between a waste that is highly toxic, ignitable, corrosive and reactive, and one that is only toxic.

State of Michigan

The State of Michigan Department of Natural Resources degree of hazard scheme is one component of a broader waste classification process to determine appropriate levels of waste regulation. The hazard assessment method was presented in the June 11, 1980 State of Michigan Department of Natural Resources Draft Proposed Administrative Rules for the Hazardous Waste Management Act, Act 64 of the Public Acts of 1979. However, the hazard evaluation methodology was not incorporated in the final February 5, 1981, rules passed by the legislature and so has never been implemented. This section addresses only the degree of hazard component of the proposed rules, not the overall classification scheme. The overall classification scheme is described in Chapter 5.

Basis of Scheme

The Michigan scheme is based on a consideration of seven different waste constituent properties related to toxicity and persistence. Based on an evaluation of these variables, a waste constituent is assigned a hazard rating (i.e., "A"-"D", with "A" being the most hazardous). Substances classified in Toxicity Category A are subject to the most stringent quantity/concentration requirements that determine regulatory status. Those constituents classified in Toxicity Category D are subject to the least stringent quantity/concentration requirements. In a manner similar to the method employed by the Washington scheme, the assigned hazard rating is factored into a quantity/concentration formula to determine the waste designation for management purposes.

Table 11 presents a summary of the Michigan approach to scoring toxic chemicals. As is evident from Table 11, the various properties by which the constituents are ranked are not evaluated along the same numerical scale. These discrepancies reflect an intention to weight constituent properties differently in the hazard evaluation. The guidelines presented in Table 12 are applied in the computation of the hazard classifications.

As is evident from Table 12 the assignment of toxicity categories according to the Michigan scheme is not solely based on the sum of the scores for the seven individual tests; rather, it is based on a formula tailored to weight the various factors. The sum of factor scores is figured into the determination of "B" and "C" category wastes. The "A" category is, however, not assigned based on the component total score.

Table 11

Toxicity Scoring for Determination of Toxicity Category for Michigan State Degree of Hazard Assessment Scheme[1]

1. ACUTE TOXICITY

Score is determined based on the highest scoring acute toxicity test result according to the following range of values.

Score	Oral LD_{50}	Dermal LD_{50}	Aquatic LC_{50}	Inhalation LC_{50}
7 (Extremely Toxic)	<5 mg/kg	<5 mg/kg	<1 mg/l	<500 g/l
5 (Highly Toxic)	5-50 mg/kg	5-200 mg/kg	1-10 mg/l	500-2000 g/l
3 (Moderately Toxic)	>50-500 mg/kg	>200-500 mg/kg	>10-100 mg/l	>2000-20000 g/l
1 (Slightly Toxic)	>0.5-5 g/kg	>0.5-5 g/kg	>100-1000 mg/l	>20000-50000 g/l
0 (Relatively	>5 g/kg	>5 g/kg	>1000 mg/l	>50000 g/l

2. CARCINOGENICITY

Score	Testing Results
7	The substance has been demonstrated to be a human positive, potential human, or animal positive carcinogen by the oral, dermal or inhalation route of exposure based on data reported by the International Agency for Research on Cancer, National Cancer Institute, or National Institute for Occupational Safety and Health.
5	The substance has been demonstrated to be a potential animal carcinogen by the oral, dermal, or inhalation route of exposure.
3	The substance has been demonstrated to be an animal positive or potential animal carcinogen by any route other than oral, dermal, or inhalation, or has been demonstrated by accepted mutagenicity screening tests or accepted cell transformation studies to be a strongly suspect carcinogen.
1	The substance has been demonstrated by accepted mutagenicity tests or accepted cell transformation studies to be a suspect carcinogen.
0	The substance has been tested by the above systems and has not been demonstrated to cause cancer or to be a suspect carcinogen.

3. HEREDITARY MUTAGENICITY

Score	Category
7	Confirmed hereditary mutagen
5	Potential hereditary mutagen in multicellular organisms
3	Potential hereditary mutagen in microorganisms
0	Not demonstrated to be a hereditary mutagen

4. TERATOGENICITY

Score	Category
7	Confirmed teratogen
5	Potential teratogen
0	Not teratogenic

5. PERSISTENCE

Score		t 1/2 in Air, Soil, or Water (expressed in weeks)
4	(Very persistent)	>52
3	(Persistent)	40-52
2	(Slowly degradable)	27-39
1	(Moderately degradable)	14-26
0	(Degradable)	1-13
-1	(Readily degradable)	<1
-2	(Rapidly degradable)	<1 day

6. BIOACCUMULATION

Score	Bioaccumulation	Log P (used when actual bioaccumulation data are not available)
7	>4000x	>6.00
5	1000-3999x	5.00-5.99
3	700-999x	4.50-4.99
1	300-699x	3.50-4.49
0	<300x	<3.50

7. OTHER ADVERSE EFFECTS

7a. Terrestrial Animals:

Score	Category
7	Produces an irreversible adverse effect at a very low dose (i.e. 0.5 mg/kg) by oral, dermal or inhalation routes.
5	Irreversible adverse effects during or following cessation of low level exposure by oral, dermal or inhalation routes.
3	Reversible adverse effects following cessation of low level exposure by oral, dermal or inhalation routes.
0	No detectable adverse effects.

7b. Aquatic Organisms:

Score	EC50
7	<0.1 mg/l
5	0.1 - 1 mg/l
3	>1 - 10 mg/l
1	>10 - 100 mg/l
0	>100 mg/l

---

[1] THE CRITERIA DEFINING THE VARIOUS SUBCATEGORIES ARE FURTHER EXPLAINED IN THE TEXT OF CHAPTER 5.

TABLE 12

COMPUTATION OF SCORES AND DETERMINATION OF TOXICITY CATEGORY

Hazard Classification	Classification Criteria
A	One or more components of the waste must score 7 in 2 or more factors.
B	One or more components of the waste must have an individual total score of 7 or greater.
C	One or more components of the waste must have an individual total score of 5 or 6.
D	One or more components of the waste must score a 3 in acute toxicity, carcinogenicity, or other adverse effects.

Table 13 provides a comparison of two hypothetical constituents to demonstrate the hazard category determination process. The hypothetical constituent A in Table 13 has a total store of 34 and a hazard rating of "B." This constituent rates the next to the highest score in every category with a potential maximum subscore of 7. Constituent B has a total score of 17 but a hazard rating of "A" because it scores 7's in two categories, bioaccumulation and other adverse effects.

Although the examples provided in Table 13 represent two somewhat extreme applications of the Michigan scheme, they demonstrate the scoring approach.

Application of Scheme

Step 1: Identification of toxic constituents and constituent concentrations

As was the case in the Washington degree of hazard assessment, the first step of the Michigan process involves the identificatiohn of waste stream constituents and constituent concentrations. The case study facility K025.1 reportedly generates a waste stream manifesting the characteristics described on page 22.

Step 2: Hazard categorization of waste stream constituents

The next step in the Michigan hazard assessment process involves the evaluation of constituents in terms of the seven categories presented in Table 11 and the assignment of a hazard classification to each constituent.

The Michigan DNR proposed rules document includes a list of substances for which hazard classifications have been computed. Table 14 summarizes the ranking process for the K025.1 waste stream constituents as assigned by Michigan DNR and as computed by the study team. Table 15 presents the individual subscores assigned to each constituent by the study team.

TABLE 13

MICHIGAN HAZARD CATEGORY DETERMINATION FOR TWO HYPOTHETICAL CONSTITUENTS

Constituent A			Constituent B		
Test Factor[1]	Sub Score	Characteristic	Test	Sub Score	Characteristic
1	5	Highly toxic	1	0	Relatively nontoxic
2	5	Potential animal carcinogen	2	0	The substance has been tested and has not been demonstrated to cause cancer or to be a suspect carcinogen.
3	5	Potential hereditary mutagen in multicellular organisms	3	0	Not demonstrated to be a hereditary mutagen
4	5	Potential teratogen	4	0	Not teratogenic
5	4	Very persistent	5	3	Persistent
6	5	Bioaccumulation factor: 3999X	6	7	Bioaccumulation factor: 4000X
7a	0	Produces irreversible adverse effects during or following low level exposure	7a	0	No detectable adverse effects
7b	5	EC_{50} aquatic organisms: 0.1 mg/1	7b	7	EC_{50}:0.09 mg/1
		Total Score: 34 Hazard Category: B			Total Score: 17 Hazard Category: A

---

[1] These test factor numbers correspond to the test factor numbers listed in Table 11.

TABLE 14

COMPARISON OF TOXICITY RATINGS AS DETERMINED BY STUDY TEAM AND BY MICHIGAN DNR

Constituent	Study Team Assigned Rating	Michigan DNR Assigned Rating
meta-Dinitrobenzene	C	C
2,4-Dinitrotoluene	A or B	B
Benzene	B	B
Nitrobenzene	B	D
Aniline	D	B

The application of the Michigan hazard ranking to the K025.1 waste stream points up some of the problems inherent in degree of hazard in general and this approach in particular. These problems can be categorized as related to (1) data interpretation and (2) data availability.

Problems of data interpretation are exemplified in the hereditary mutagenicity categorization of 2,4-Dinitrotoluene. The text of the Michigan DNR proposed rule states that

> (c) "Hereditary mutagen" means a substance which causes an inheritable change in genetic material, and includes:
>
> (i) "Confirmed hereditary mutagens" means substances which produce a statistically significant dose related mutagenic effect in test microorganisms without the use of metabolic activators (i.e., insect, rodent, etc.) with mutations inheritable in subsequent generations of the test organisms.
>
> (ii) "Potential hereditary mutagens" means substances which produce a statistically significant dose-related mutation in a complex multicellular organism (i.e. plants, insects, rodents, etc.) with mutations inheritable in subsequent generations of the test organism, or which produce a statistically significant dose-related mutation in exposed test microorganisms with mutations inheritable in subsequent generations.
>
> (iii) A substance is not considered to be a hereditary mutagen if it has been adequately tested in several appropriate

---

[1] Michigan Department of Natural Resources, Draft Hazardous Waste Regulation Rule 205, Lansing, Michigan. June 11, 1980, Page 17.

TABLE 15

STATE OF MICHIGAN HAZARD SCHEME RANKING FOR WASTE STREAM CONSTITUENTS PRESENT IN THE WASTE STREAM GENERATED BY CASE STUDY FACILITY K025.1

Constituent: meta-Dinitrobenzene

Test	Subscore	Characteristic
1.	5	Highly Toxic (LD_{50}: 30 mg/kg)
2.	-	No data
3.	-	Insufficient data
4.	-	No data
5.	0	Degradable: t1/2 in soil or water 8 weeks
6.	-	Low bioaccumulation potential
7a.	-	No data
7b.	-	No data

Toxicity category based on available data: C

Constituent: 2,4-Dinitrotoluene

Test	Subscore	Characteristic
1.	3	Moderately toxic (LD_{50}: 268 mg/kg)
2.	7	Carcinogenic (listed by IARC)
3.	7 or 5	Confirmed animal mutagen
4.	-	No data
5.	4	Very persistent (persistence in unadapted soil: 3-18 months)
6.	0	Bioaccumulation factor: 5.5 - 19
7a.	-	No data
7b.	-	No data

Toxicity category based on available data: A or B

Constituent: Benzene

Test	Subscore	Characteristic
1.	3	Moderately toxic (aquatic LC_{50}: 20-22 mg/1)
2.	7	Carcinogenic (listed by IARC)
3.	0	Not demonstrated to be mutagenic
4.	5	Potential teratogen
5.	3	Difficult to degrade
6.	0	Bioconcentration factor: 24
7.a	-	No data
7.b	-	No data

Toxicity category based on available data: B

TABLE 15

(Continued)

Constituent: Nitrobenzene

Test	Subscore	Characteristic
1.	3	Aquatic LC_{50}: 42.6 mg/1
2.	5	Suspected carcinogen
3.	0	Not demonstrated to be mutagenic
4.	5	Suspected animal teratogen
5.	4	Very difficult to degrade
6.	0	Bioconcentration factor: 15
7.a	-	No data
7.b	1	Aquatic EC_{50}: 27 mg/1

Toxicity category based on available data: B

Constituent: Aniline

Test	Subscore	Characteristic
1.	3	Moderately toxic (LD_{50}: 41 mg/kg)
2.	-	Insufficient evidence to support carcinogenicity determination (IARC)
3.	-	No data
4.	-	No data
5.	-	No data
6.	0	Bioaccumulation factor: 4
7.a	-	No data
7.b	-	No data

Toxicity category based on available information: D

The data as reported in the commonly available sources do not provide the requisite detail to determine if 2,4-dinitrotoluene should be scored "7" or "5" in this category. The source states that: 2,4-dinitrotoluene was mutagenic in the dominant lethal assay in Salmonella typhimurium strain TA 1535 (Hodgson, et al. 1976). Cultures of lymphocytes and kidney cells derived from the rats fed 2,4-dinitrotoluene had significant increases in the frequency of chromatid gaps but not in translocations or chromatid breaks (Hodgson, et al. 1976).

The mutagenic effects of products from ozonation or chlorination of 2,4-dinitrotoluene and other dinitrotoluenes were negative in one study (Simmon, et al. 1977) and, of products from ozonation alone, were ambiguous in another study (Cotruvo, et al. 1977).[1] References are provided for those who wish to pursue the point, but these sources would not be commonly available to most individuals. The data source for this category, in this case, affects the ultimate hazard category assigned to the constituent. During the course of the study, similar dilemmas were routinely encountered and would be anticipated to occur if a degree of hazard system of this complexity were implemented on a nationwide basis.

The case of data availability is most clearly exemplified in the case of the aniline categorization. Data were only available in the conventional sources for two of the seven parameters required to categorize this constituent. In this case, Michigan had already categorized the constituent and presumably employed additional data sources. A lack of data in a category counts as a zero for that category in this scheme, and so can have a dramatic effect on the ultimate categorization.

Step 3: Consideration of hazard category, and quantity of waste generated: designation of management category

Unlike the Washington scheme, the Michigan scheme does not involve application of an "equivalent concentration" concept in waste management designation. Rather, the Michigan degree of hazard approach evaluates each constituent individually, and if any constituent warrants "managed" status according to the prescribed quantity/concentration formula, the entire waste is managed under Act 64.

For each hazard category (e.g. "A", "B", "C", & "D") a graph is available which represents the quantity/concentration formula for wastes in the respective hazard categories. The specific hazard category graphs are presented in Figures 3 through 6. Table 16 summarizes the K025.1-specific information leading to the determination of the management category for the individual constituents and for the waste stream as plotted on Figures 3 through 6.

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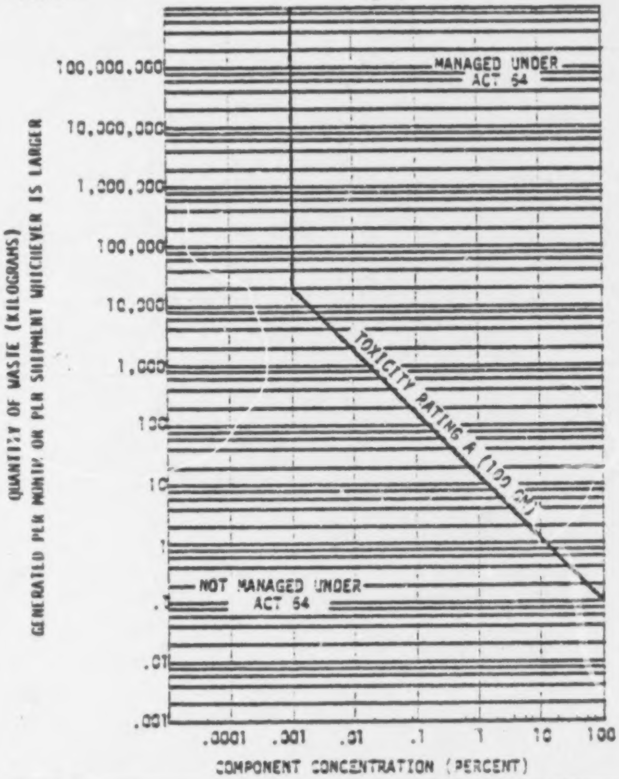
[1] USEPA, OSW, Background Document, RCRA, Subtitle C - Identification and Listing of Hazardous Wastes, Appendix A: Health & Environmental Effects, Washington, D.C. May 1980, p. 1090.

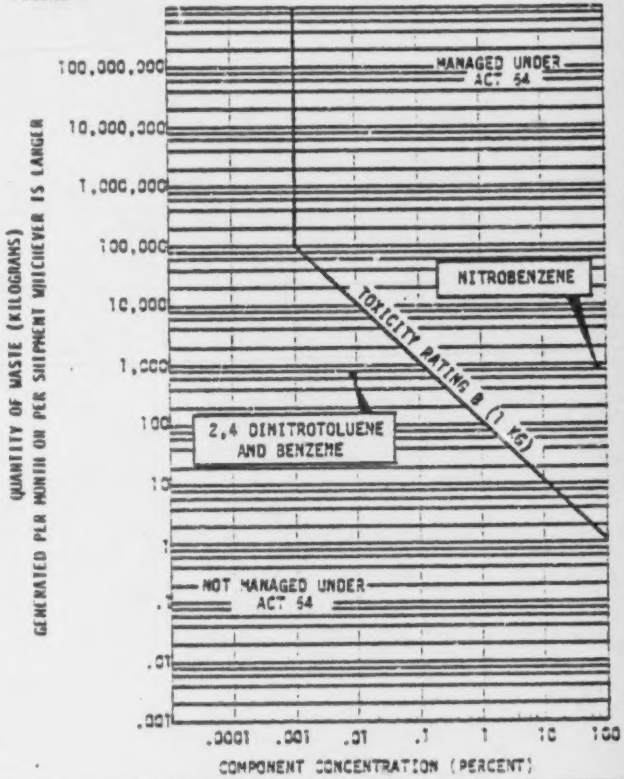
Designation of Hazardous Wastes by Michigan Department of Natural Resources for Constituents of K025.1

FIGURE 3



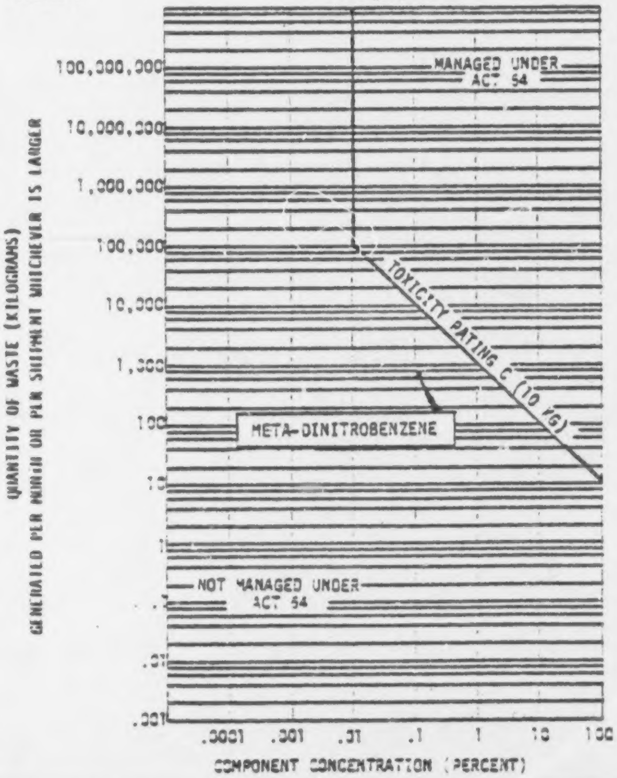
Category A

FIGURE 4



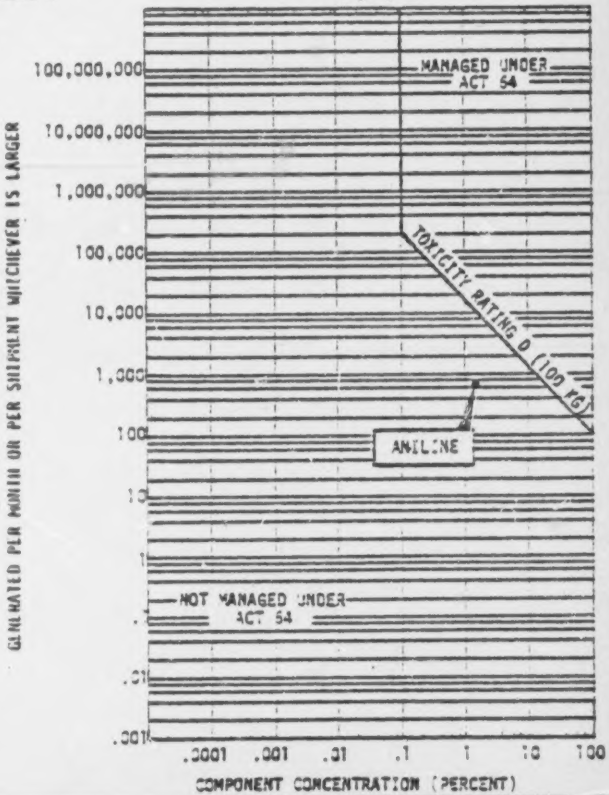
Category B

FIGURE 5



Category C

FIGURE 6



Category D.

TABLE 16

MICHIGAN DEPARTMENT OF NATURAL RESOURCES
MANAGEMENT DESIGNATIONS OF WASTE
GENERATED BY FACILITY K025.1
(WASTE GENERATION 624 kg/mo)

Constituent	Hazard Category	Concentration in %	Management Designation
meta-Dinitrobenzene	C	0.1-0.2	Unmanaged
2,4-Dinitrotoluene	B	<0.01	Unmanaged
Benzene	B	0.01	Unmanaged
Nitrobenzene	B	96-98	Managed
Aniline	D	1-1.5	Unmanaged

The relationships portrayed in Figures 3-6 demonstrate that this waste is managed not because of the levels of its four most hazardous constituents, but because of the high concentrations of nitrobenzene, the constituent with the lowest hazard rating. In order for this waste to be redesignated as unmanaged, either the quantity generated or the percent composition of nitrobenzene would have to be reduced. Of course, as the percentage composition of nitrobenzene is reduced, some other constituent will correspondingly increase in percentage composition. Since nitrobenzene receives the scheme's lowest hazard rating, D, the only constituents which could increase in percentage composition to offset the decrease in nitrobenzene would be non-hazardous ones. This relationship recalls the familiar "solution to pollution in dilution" formula. Table 17 presents the quantity/concentration relationship which would have to be satisfeid to recategorize this waste as unmanaged.

Consideration of Handling Hazards

The degree of hazard component of the Michigan scheme is similar to that of the Washington scheme in that it addresses issues related to the potential long term hazards associated with land disposal of hazardous wastes. It does not address waste handling issues directly through the degree of hazard approach. These issues (e.g. ignitability, corrosivity, and reactivity) are considered in the classification approach but not in the degree of hazard element of that approach. Both handling and long range hazards can result in the scheme's most stringent management designation.

TABLE 17

QUANTITY/CONCENTRATION REQUIREMENTS TO EXEMPT THE WASTE OF FACILITY K025.1 FROM MANAGEMENT UNDER ACT 64

Constituent	Hazard Category	Actual Waste Quantity	Actual Concentration	Waste Quantity Required for Unmanaged Status at Actual Concentration	Component Concentration Required for Unmanaged Status at Actual Quantity Generated
Nitrobenzene	D	624 kg/mo	96-98%	100 kg/mo	15%

JRB Associates Environmental Containment Waste Characterization Scheme

The JRB classification scheme was originally designed to evaluate land disposal sites containing hazardous wastes, to rank them for remedial action priority. Although this approach stands somewhat apart from the waste-based degree of hazard concept, the method's evaluations of environmental site features and management practices suggest a potential to further the state of the art of hazard assessment. This system was designed specifically for application to land disposal situations. A similar system could be devised to address site-specific and management-specific aspects of other disposal alternatives such as incineration or landfarming.

Basis of Scheme

The JRB classification scheme involves site- and waste-specific variables which are grouped into four categories:

1. Waste characteristics: consideration of the types of potential hazards posed by the wastes.
2. Waste management: consideration of the quality of facility design and operation.
3. Pathways: consideration of the potential mechanisms of migration.
4. Receptors: identification of potential targets of chemical hazards.

For each of the 31 variables, the values or characteristics of that variable are partitioned into four rating scale levels to allow the development of numerical evaluations. The variables, their categorization and the corresponding rating scale levels are depicted in Table 18, excerpted from the JRB Methodology Document. Table 19 provides a summary of the significance of 31 component variables, as prepared by JRB.

For the actual computation of the rating for a given waste disposal situation, the 31 variables have been assigned multipliers to compensate for differences in their significance in the evaluation process. These assigned multipliers remain constant for all disposal sites. The basic procedure for scoring involves (1) determining the appropriate rating scale level for a given circumstance; (2) multiplying the numeric value of that level by the corresponding multiplier; (3) adding the products of the 31 factors; (4) dividing by the maximum possible score; and (5) multiplying by 100. A higher score indicates a higher hazard potential. Unlike the Michigan scheme, the JRB approach provides a space to note the number of considerations for which no data are available.

The JRB system provides for the consideration of additional site, management or waste attributes which influence hazard potential. Such considerations are evaluated in the "additional points" categories in each of the four groups of variables displayed on the sample rating form. The kinds of factors addressed under the additional points category are

TABLE 18

RATING SCALE LEVELS FOR BASIC CATEGORIES

RATING FACTORS	RATING SCALE LEVELS			
	0	1	2	3
RECEPTORS				
POPULATION WITHIN 1,000 FEET	0	1 TO 25	26 TO 100	GREATER THAN 100
DISTANCE TO NEAREST DRINKING-WATER WELL	GREATER THAN 3 MILES	1 TO 3 MILES	3,001 FEET TO 1 MILE	0 TO 3,000 FEET
DISTANCE TO NEAREST OFF-SITE BUILDING	GREATER THAN 2 MILES	1 TO 2 MILES	1,001 FEET TO 1 MILE	0 TO 1,000 FEET
LAND USE. ZONING	COMPLETELY REMOTE (ZONING NOT APPLICABLE)	AGRICULTURAL	COMMERCIAL OR INDUSTRIAL	RESIDENTIAL
CRITICAL ENVIRONMENTS	NOT A CRITICAL ENVIRONMENT	PRISTINE NATURAL AREAS	WETLANDS, FLOODPLAINS, AND PRESERVED AREAS	MAJOR HABITAT OF AN ENDANGERED OR THREATENED SPECIES
PATHWAYS				
EVIDENCE OF CONTAMINATION	NO CONTAMINATION	INDIRECT EVIDENCE	POSITIVE PROOF FROM DIRECT OBSERVATION	POSITIVE PROOF FROM LABORATORY ANALYSES
LEVEL OF CONTAMINATION	NO CONTAMINATION	LOW LEVELS, TRACE LEVELS, OR UNKNOWN LEVELS	MODERATE LEVELS OR LEVELS THAT CANNOT BE SENSED DURING A SITE VISIT BUT WHICH CAN BE CONFIRMED BY A LABORATORY ANALYSIS	HIGH LEVELS OR LEVELS THAT CAN BE SENSED EASILY BY INVESTIGATORS DURING A SITE VISIT
TYPE OF CONTAMINATION	NO CONTAMINATION	SOIL CONTAMINATION ONLY	BIOTA CONTAMINATION	AIR WATER, OR FOODSTUFF CONTAMINATION
DISTANCE TO NEAREST SURFACE WATER	GREATER THAN 5 MILES	1 TO 5 MILES	1,001 FEET TO 1 MILE	0 TO 1,000 FEET
DEPTH TO GROUNDWATER	GREATER THAN 100 FEET	51 TO 100 FEET	21 TO 50 FEET	0 TO 20 FEET
NET PRECIPITATION	LESS THAN -10 INCHES	-10 TO -5 INCHES	-5 TO -20 INCHES	GREATER THAN -20 INCHES
SOIL PERMEABILITY	GREATER THAN 50% CLAY	30% TO 50% CLAY	15% TO 30% CLAY	0 TO 15% CLAY
BEDROCK PERMEABILITY	IMPERMEABLE	RELATIVELY IMPERMEABLE	RELATIVELY PERMEABLE	VERY PERMEABLE
DEPTH TO BEDROCK	GREATER THAN 60 FEET	31 TO 60 FEET	11 TO 30 FEET	0 TO 10 FEET

TABLE 18
(continued)

RATING FACTORS	RATING SCALE LEVELS			
	0	1	2	3
WASTE CHARACTERISTICS				
TOXICITY	SAX'S LEVEL 0 OR NFPA'S LEVEL 0	SAX'S LEVEL 1 OR NFPA'S LEVEL 1	SAX'S LEVEL 2 OR NFPA'S LEVEL 2	SAX'S LEVEL 3 OR NFPA'S LEVELS 3 OR 4
RADIOACTIVITY	AT OR BELOW BACKGROUND LEVELS	1 TO 3 TIMES BACKGROUND LEVELS	3 TO 5 TIMES BACKGROUND LEVELS	OVER 5 TIMES BACKGROUND LEVELS
PERSISTENCE	EASILY BIODEGRADABLE COMPOUNDS	STRAIGHT CHAIN HYDROCARBONS	SUBSTITUTED AND OTHER RING COMPOUNDS	METALS, POLYCYCLIC COMPOUNDS, AND HALOGENATED HYDROCARBONS
IGNITABILITY	FLASH POINT GREATER THAN 200° OR NFPA'S LEVEL 0	FLASH POINT OF 140°F. to 200°F. OR NFPA'S LEVEL 1	FLASH POINT OF 80°F. TO 140°F. OR NFPA'S LEVEL 2	FLASH POINT LESS THAN 80°F. OR NFPA'S LEVELS 3 OR 4
REACTIVITY	NFPA'S LEVEL 0	NFPA'S LEVEL 1	NFPA'S LEVEL 2	NFPA'S LEVELS 3 OR 4
CORROSIVENESS	pH OF 6 TO 9	pH OF 5 TO 6 OR 9 TO 10	pH OF 3 TO 5 OR 10 TO 12	pH OF 1 TO 3 OR 12 TO 14
SOLUBILITY	INSOLUBLE	SLIGHTLY SOLUBLE	SOLUBLE	VERY SOLUBLE
VOLATILITY	VAPOR PRESSURE LESS THAN 0.1 mm Hg	VAPOR PRESSURE OF 0.1 TO 25 mm Hg	VAPOR PRESSURE OF 78 TO 25 mm Hg	VAPOR PRESSURE GREATER THAN 78 mm Hg
PHYSICAL STATE	SOLID	SLUDGE	LIQUID	GAS
WASTE MANAGEMENT PRACTICES				
SITE SECURITY	SECURE FENCE WITH LOCK	SECURITY GUARD BUT NO FENCE	REMOTE LOCATION OR BREACHABLE FENCE	NO BARRIERS
HAZARDOUS WASTE QUANTITY	0 TO 250 TONS	251 TO 1,000 TONS	1,001 TO 2000 TONS	GREATER THAN 2,000 TONS
TOTAL WASTE QUANTITY	0 TO 10 ACRE FEET	11 TO 100 ACRE FEET	101 TO 250 ACRE FEET	GREATER THAN 250 ACRE FEET
WASTE INCOMPATIBILITY	NO INCOMPATIBLE WASTES ARE PRESENT	PRESENT, BUT DOES NOT POSE A HAZARD	PRESENT AND MAY POSE A FUTURE HAZARD	PRESENT AND POSING AN IMMEDIATE HAZARD
USE OF LINERS	CLAY OR OTHER LINER RESISTENT TO ORGANIC COMPOUNDS	SYNTHETIC OR CONCRETE LINER	ASPHALT-BASE LINER	NO LINER USED
USE OF LEACHATE COLLECTION SYSTEMS	ADEQUATE COLLECTION AND TREATMENT	INADEQUATE COLLECTION OR TREATMENT	INADEQUATE COLLECTION AND TREATMENT	NO COLLECTION OR TREATMENT
USE OF GAS COLLECTION SYSTEMS	ADEQUATE COLLECTION AND TREATMENT	COLLECTION AND CONTROLLED FLARING	VENTING OR INADEQUATE TREATMENT	NO COLLECTION OR TREATMENT
USE AND CONDITION OF CONTAINERS	CONTAINERS ARE USED AND APPEAR TO BE IN GOOD CONDITION	CONTAINERS ARE USED BUT A FEW ARE LEAKING	CONTAINERS ARE USED BUT MANY ARE LEAKING	NO CONTAINERS ARE USED

Source: JRB Associates

TABLE 19

SIGNIFICANCE OF JRB CLASSIFICATION RATING VARIABLES

Receptor Category Variables

- "Residential population within 1,000 feet" and "distance to the nearest off-site building" measure the potential for human exposure to the site.
- "Distance to the nearest drinking-water well" measures the potential for human ingestion of the contaminants should underlying aquifers be polluted.
- "Land use/zoning" evaluates the current and anticipated uses of the surrounding area.
- "Critical environments" assesses the potential for adversely affecting important biological resources and fragile natural settings.

Pathway Category Variables

- "Distance to the nearest surface water" and "depth to groundwater" measure the availability of pollutant migration routes.
- "Soil permeability," "bedrock permeability", and "depth to bedrock" measure the potential for contaminant attenuation and ease of migration.
- "Net precipitation" uses annual precipitation and evapo-transpiration to estimate the amount of leachate a site produces.
- "Evidence of contamination," "type of contamination," and "level of contamination" evaluate pollution currently apparent at the site.

Waste Characteristic Variables

- "Solubility," "volatility," and "physical state" measure the extent to which mobile wastes can leave the site.
- "Toxicity", "radioactivity," and "persistence" assess the site's potential to cause health-related injuries.
- "Ignitability," "reactivity," and "corrosiveness" evaluate the possibility of fire, explosion, or similar emergencies.

Waste Management Practice Variables

- "Use of leachate collection systems," "use of gas collection systems," and "use of liners" examine features of site design for containing contamination.
- "Site security" assesses the measures taken to limit site access.
- "Total waste quantity" and "hazardous waste quantity" measure the quantity of waste in the site, and thus, the potential magnitude of resulting contamination.
- "Waste incompatibility" evaluates the potential for incompatible wastes to combine and pose a hazard.
- "Use of containers" assesses the adequacy of using containers to isolate wastes.

summarized in Table 20. Except for additional points for waste characteristics, these considerations were not factored into the JRB case applications because they rely on first-hand observation of site attributes. The case study facility profiles were developed through telephone interviews, rather than on-site visits.

The study team profiled three actual disposal sites according to their receptor classification, pathway classification and certain aspects of the waste management practices classification. Waste quantity characteristics and waste incompatibility characteristics were not recorded at this stage. Then the waste streams from all facilities were evaluated assuming the same site characteristics. This approach allowed an evaluation of the suitability of a given site for disposal of the various waste types and quantities for each case study waste. These results indicate the influence of site characteristics on degree of hazard according to the JRB method.

Application of Scheme

Step 1: Development of site specific and disposal practice information for three unidentified facilities selected from the case study sample.

The 31 variables addressed in the JRB scheme can be divided into two groups: (1) Those variables which are site- and site-management-specific; and (2) Those variables which are waste stream-specific, these being more representative of the considerations on which the Washington and Michigan schemes are based. The waste-specific variables were determined to be all those parameters considered under the heading "Waste Characteristics" and three of the parameters considered under the heading "Waste Management Practices." These three variables are hazardous waste quantity; total quantity; and waste incompatibility. All other variables were considered to be site-specific.

The study team developed site-specific/management-specific profiles for three case study facilities, which out of deference to the facility operators remain unidentified. These site-specific profiles provide a backdrop for an evaluation of a site's suitability to receive/dispose the array of case study waste streams as evaluated by the JRB scheme. The site-specific/management-specific profiles employed in the project are provided as Tables 21-23 on the site ranking forms designed by JRB.

Tables 21-23 present the scoring for the three facilities independent of a consideration of the waste streams which are actually disposed there. Table 24 presents their relative rankings in that context. The higher the score is, the higher the potential hazard.

The interpretation of the scores for the three facilities requires some consideration of the weighting factors involved in their derivation. Of all factors considered, population within 1,000 feet (receptor category) has been assigned the scheme's highest multiplier (12). The next highest, multiplier (8), has been assigned to only three of the 31 categories: distance to nearest drinking water well, distance to nearest off-site

TABLE 20

TYPICAL ISSUES ADDRESSED IN THE "ADDITIONAL POINTS" CATEGORY OF THE JRB WASTE DISPOSAL CLASSIFICATION SCHEME[1]

RECEPTORS (50 points maximum allowed in this category)

- Use of site by local residents
- Neighboring land use
- Neighboring transportation routes, drinking water supplies, and important natural resources

PATHWAYS (25 points maximum allowed in this category)

- Extreme runoff and erosion problems
- Slope instability
- Flooding
- Seismic activity

WASTE CHARACTERISTICS (20 points maximum allowed in this category)

- Carcinogenicity, mutagenicity, and teratogenicity
- Infectiousness
- Low biodegradability
- High-level radioactivity

WASTE MANAGEMENT PRACTICES (30 points maximum allowed in this category)

- Excessively large waste quantities
- Open burning of wastes
- Site abandonment
- Unsafe disposal practices
- Inadequate cover
- Inadequate safety precautions
- Inadequate record keeping

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[1] For further explanation of the additional points calculation see JRB Associates, "Methodology for Rating the Hazard Potential of Waste Disposal Sites, JRB Associates, McLean, VA 1980.

Table 21

Landfill #1: Site-Specific JRB Evaluation by Assessment Method

RATING FACTOR	SOURCE AND BASIS OF INFORMATION	FACTOR RATING (CIRCLE ONE)	MULTI-PLIER	FACTOR SCORE	MAXIMUM POSSIBLE SCORE
RECEPTORS					
POPULATION WITHIN 1,000 FEET	5	0 [✓ 1] 2 3	12	12	36
DISTANCE TO NEAREST DRINKING WATER WELL	700 ft.	0 1 2 [✓ 3]	8	24	24
DISTANCE TO NEAREST OFF-SITE BUILDING	700 ft.	0 1 2 [✓ 3]	8	24	24
LAND USE/ZONING	Residential/agriculture	0 [✓ 1] 2 3	6	6	18
CRITICAL ENVIRONMENTS	Drainage ditch/wetlands	0 1 [✓ 2] 3	6	12	18
ADDITIONAL POINTS FOR OTHER RECEPTORS					~~50~~
NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 5			SUBTOTALS	78	120
PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		65
PATHWAYS					
EVIDENCE OF CONTAMINATION	(after heavy rain)	0 1 2 [✓ 3]	2	6	6
LEVEL OF CONTAMINATION		0 1 [✓ 2] 3	7	14	21
TYPE OF CONTAMINATION	Water	0 1 2 [✓ 3]	5	15	15
DISTANCE TO NEAREST SURFACE WATER	1 mile	0 [✓ 1] 2 3	8	8	24
DEPTH TO GROUNDWATER	Approx. 9'	0 1 2 [✓ 3]	7	21	21
NET PRECIPITATION	Approx. 50"/yr	0 1 2 [✓ 3]	6	18	18
SOIL PERMEABILITY	Sandy soil	0 1 2 [✓ 3]	6	18	18
BEDROCK PERMEABILITY		~~0 1 2 3~~	~~4~~		~~12~~
DEPTH TO BEDROCK	>700'	[✓ 0] 1 2 3	4	0	12
ADDITIONAL POINTS FOR OTHER PATHWAYS					~~25~~
NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 9			SUBTOTALS	100	135
PERCENTAGE OF MISSING AND ASSUMED VALUES = 11.11 %			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		74

WASTE MANAGEMENT PRACTICES					
SITE SECURITY	Locked fence	[✓ 0] 1 2 3	7	0	21
HAZARDOUS WASTE QUANTITY	Waste-specific	~~0 1 2 3~~	~~7~~		~~21~~
TOTAL WASTE QUANTITY	Waste-specific	~~0 1 2 3~~	~~5~~		~~15~~
WASTE INCOMPATIBILITY	Waste-specific	~~0 1 2 3~~	~~5~~		~~15~~
USE OF LINERS	Bentonite	[✓ 0] 1 2 3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0 1 2 [✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0] 1 2 3	2	0	6
USE AND CONDITION OF CONTAINERS	None	0 1 2 [✓ 3]	2	6	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES					~~30~~
NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 5			SUBTOTALS	15	51
PERCENTAGE OF MISSING AND ASSUMED VALUES = 37.5 %			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		29

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 19

PERCENTAGE OF MISSING AND ASSUMED VALUES = 5.26 %

TOTAL FACTOR SCORE 193

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 306

OVERALL SCORE 63
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

Table 22
Landfill #2: Site-Specific JRB Evaluation by Assessment Method

RATING FACTOR	SOURCE AND BASIS OF INFORMATION	FACTOR RATING (CIRCLE ONE)	MULTIPLIER	FACTOR SCORE	MAXIMUM POSSIBLE SCORE
RECEPTORS					
POPULATION WITHIN 1,000 FEET	6	0 [✓ 1] 2 3	12	12	36
DISTANCE TO NEAREST DRINKING WATER WELL	1/4 mile	0 1 2 [✓ 3]	8	24	24
DISTANCE TO NEAREST OFF-SITE BUILDING	1/4 mile	0 1 [✓ 2] 3	8	16	24
LAND USE/ZONING	Industrial	0 1 [✓ 2] 3	6	12	18
CRITICAL ENVIRONMENTS	River	0 1 [✓ 2] 3	6	12	18
ADDITIONAL POINTS FOR OTHER RECEPTORS					~~50~~
NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8			SUBTOTALS	76	120
PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		63
PATHWAYS					
EVIDENCE OF CONTAMINATION		[✓ 0] 1 2 3	2	0	6
LEVEL OF CONTAMINATION		[✓ 0] 1 2 3	7	0	21
TYPE OF CONTAMINATION		[✓ 0] 1 2 3	5	0	15
DISTANCE TO NEAREST SURFACE WATER	1/4 mile	0 1 [✓ 2] 3	8	16	24
DEPTH TO GROUNDWATER	5-40 ft.	0 1 2 3	7	21	21
NET PRECIPITATION	Approx. 64"	0 1 2 [✓ 3]	6	18	18
SOIL PERMEABILITY	10^{-4} - 10^{-5} cm/sec.	0 [✓ 1] 2 3	6	6	18
BEDROCK PERMEABILITY		~~0 1 2 3~~	~~4~~		~~12~~
DEPTH TO BEDROCK		~~0 1 2 3~~	~~4~~		~~12~~
ADDITIONAL POINTS FOR OTHER PATHWAYS					~~25~~
NUMBER OF MISSING AND ASSUMED VALUES = 2 OUT OF 9			SUBTOTALS	61	123
PERCENTAGE OF MISSING AND ASSUMED VALUES = 22.22 %			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		50

WASTE MANAGEMENT PRACTICES					
SITE SECURITY	Locked fence	[✓ 0] 1 2 3	7	0	21
HAZARDOUS WASTE QUANTITY	Waste-specific	~~0 1 2 3~~	~~7~~		~~21~~
TOTAL WASTE QUANTITY	Waste-specific	~~0 1 2 3~~	~~5~~		~~15~~
WASTE INCOMPATIBILITY	Waste-specific	~~0 1 2 3~~	~~5~~		~~15~~
USE OF LINERS	Yes	[✓ 0] 1 2 3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	Yes	[✓ 0] 1 2 3	3	0	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0] 1 2 3	2	0	6
USE AND CONDITION OF CONTAINERS	Good	[✓ 0] 1 2 3	2	0	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES					~~30~~
NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 5			SUBTOTALS	0	51
PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		0

NUMBER OF MISSING AND ASSUMED VALUES = 2 OUT OF 19

PERCENTAGE OF MISSING AND ASSUMED VALUES = 10.53 %

TOTAL FACTOR SCORE 137

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 294

OVERALL SCORE 47
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

Table 23
Landfill #3: Site-Specific JRB Evaluation by Assessment Method

RATING FACTOR	SOURCE AND BASIS OF INFORMATION	FACTOR RATING (CIRCLE ONE)				MULTIPLIER	FACTOR SCORE	MAXIMUM POSSIBLE SCORE
RECEPTORS								
POPULATION WITHIN 1,000 FEET	0	[✓ 0]	1	2	3	12	0	36
DISTANCE TO NEAREST DRINKING WATER WELL	> 1/2 mile	0	1	[✓ 2]	3	8	16	24
DISTANCE TO NEAREST OFF-SITE BUILDING	1/4 mile	0	1	[✓ 2]	3	8	16	24
LAND USE/ZONING	Comm./Ind./Res.	0	1	[✓ 2]	3	6	12	18
CRITICAL ENVIRONMENTS	Creek, flood plain	0	1	[✓ 2]	3	6	12	18
ADDITIONAL POINTS FOR OTHER RECEPTORS								~~50~~
						SUBTOTALS	56	120

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 5.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100) 47

RATING FACTOR	SOURCE AND BASIS OF INFORMATION	FACTOR RATING (CIRCLE ONE)				MULTIPLIER	FACTOR SCORE	MAXIMUM POSSIBLE SCORE
PATHWAYS								
EVIDENCE OF CONTAMINATION		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
LEVEL OF CONTAMINATION		~~0~~	~~1~~	~~2~~	~~3~~	~~7~~		~~21~~
TYPE OF CONTAMINATION		~~0~~	~~1~~	~~2~~	~~3~~	~~5~~		~~15~~
DISTANCE TO NEAREST SURFACE WATER	< 1 mile	0	1	[✓ 2]	3	8	16	24
DEPTH TO GROUNDWATER	11-30 ft	0	1	[✓ 2]	3	7	14	21
NET PRECIPITATION	Approx. 45 in./yr.	0	1	2	[✓ 3]	6	18	18
SOIL PERMEABILITY	Fine clay (loess)	[✓ 0]	1	2	3	6	0	18
BEDROCK PERMEABILITY		0	1	2	3	4		12
DEPTH TO BEDROCK	60 ft.	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER PATHWAYS								~~25~~
						SUBTOTALS	52	105

NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 33.33 %.

SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100) 50

RATING FACTOR	SOURCE AND BASIS OF INFORMATION	FACTOR RATING (CIRCLE ONE)				MULTIPLIER	FACTOR SCORE	MAXIMUM POSSIBLE SCORE
WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Fence, guard	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	Waste-specific	~~0~~	~~1~~	~~2~~	~~3~~	~~7~~		~~21~~
TOTAL WASTE QUANTITY	Waste-specific	~~0~~	~~1~~	~~2~~	~~3~~	~~5~~		~~15~~
WASTE INCOMPATIBILITY	Waste-specific	~~0~~	~~1~~	~~2~~	~~3~~	~~5~~		~~15~~
USE OF LINERS	None	0	1	2	[✓ 3]	3	9	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	2	[✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS	N/A	0	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS		0	[✓ 1]	2	3	2	2	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	20	51

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 5

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100) 39

NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 19

PERCENTAGE OF MISSING AND ASSUMED VALUES = 15.79 %

TOTAL FACTOR SCORE 128

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 276

OVERALL SCORE 46
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

TABLE 24

JRB SCHEME RANKING OF THREE CASE STUDY FACILITIES INDEPENDENT OF A CONSIDERATION OF WASTE-SPECIFIC PROPERTIES

Facility	Receptor Ranking	Percentage of Missing Receptor Values	Pathway Ranking	Percentage of Missing Pathway Values	Waste Management Practice Ranking	Percentage of Missing Waste Management Values[1]	Overall Ranking Score
Facility 1	65	0	74	11	29	0	63
Facility 2	63	0	50	22	0	0	47
Facility 3	47	0	50	33	39	0	46

[1] These numbers discount the missing three waste-specific values which are ordinarily evaluated in this category.

building, and distance to nearest surface water. By contrast, the variables addressed employing the lowest multiplier (2), are: evidence of contamination; use of gas collection systems; and use and condition of containers. The JRB report does not specify the procedure by which the weighting factors were developed. A defensible nationwide degree of hazard system employing a similar method would require a thoroughly documented rationale for multiplier assignment.

As is evident from the data displayed in Table 24, the fate and transport dynamics influencing potential pollutant migration at Site 1 are significant in the score for that facility. The waste management practices of Site 2, by the JRB ranking methodology, offset the scores in the receptor and pathway categories. At Site 3, the scores for both the receptor and pathway categories are low relative to the facility sample, yet the waste management practice score is high enough to offset them. However, almost half of the variables required to evaluate the pathways characteristics of Site 3 are not available. In view of this data deficiency, it is reasonable to assume that the 50 value may be deceptively low in its assessment of constituent mobility-related hazard potential. Had the project team conducted an actual site visit as is required by the scheme, these categories would have been addressed more fully.

The interplay of these environment and management variables deserves considerable attention in the design of a degree of hazard scheme that seeks responsibly to assess the relative hazard of waste disposal situations on a nationwide basis. This analysis becomes far more meaningful as one incorporates a consideration of waste constituent toxicity, concentration, and persistence in the hazard assessment.

Step 2: Incorporation of waste-specific data in the JRB waste disposal site hazard assessment.

The waste specific data for the JRB scheme are presented for the three case study landfills in Tables 24A-26. It is important to note that these sheets represent hypothetical disposal situations for comparative purposes only and to remember that the waste generated by facility K025.1 is actually incinerated, although the literature reports that these wastes are often disposed in drums in secure landfills.

The comparative scores for the facilities independent of waste-specific data and with the incorporation of waste-specific data are presented in Table 27. Of course, in the sample case the same waste-specific data are being applied to each facility and so the relative hazard rankings of the three sites do not change as a function of the incorporation of these data. However, if the example involved several different wastes, their properties would be reflected in the final scores.

TABLE 24A

NAME OF SITE LANDFILL #1; FACILITY: K025.1 WASTE

WASTE CHARACTERISTICS								
TOXICITY	3 Constituents: Sax Rating: 3; 1:Sax Rating 2	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE		0	1	[✓ 2]	3	5	10	15
IGNITABILITY		0	1	[✓ 2]	3	3	6	9
REACTIVITY		0	1	2	[✓ 3]	3	9	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		[✓ 0]	1	2	3	4	0	12
VOLATILITY		~~0~~	~~1~~	~~2~~	~~3~~	~~4~~		~~12~~
PHYSICAL STATE		0	1	[✓ 2]	3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Carcinogenic						4	20
SUBTOTALS							58	128
SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)								45

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 11.1 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY		[✓ 0]	1	2	3	7	0	21
TOTAL WASTE QUANTITY		~~0~~	~~1~~	~~2~~	~~3~~	~~5~~		~~15~~
WASTE INCOMPATIBILITY		~~0~~	~~1~~	~~2~~	~~3~~	~~5~~		~~15~~
USE OF LINERS	Bentonite	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	2	[✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0]	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS	None	0	1	2	[✓ 3]	2	6	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
SUBTOTALS							15	72
SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)								21

NUMBER OF MISSING AND ASSUMED VALUES = 2 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 25 %.

NUMBER OF MISSING AND ASSUMED VALUES = 4 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.9 %

TOTAL FACTOR SCORE 251

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 455

OVERALL SCORE 55

(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

TABLE 25

JRB

NAME OF SITE LANDFILL #2; FACILITY: K025.1 WASTE

WASTE CHARACTERISTICS								
TOXICITY	3 Constituents: Sax rating 3; 1 sax rating 2	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE		0	1	[✓ 2]	3	5	10	15
IGNITABILITY		0	1	[✓ 2]	3	3	6	9
REACTIVITY		0	1	2	[✓ 3]	3	9	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		[✓ 0]	1	2	3	4	0	12
VOLATILITY		~~0~~	~~1~~	~~2~~	~~3~~	~~4~~		~~12~~
PHYSICAL STATE		0	1	[✓ 2]	3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS							4	20
NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 9.						SUBTOTALS	58	128
PERCENTAGE OF MISSING AND ASSUMED VALUES = 11.1 %.						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		45
WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY		[✓ 0]	1	2	3	7	0	21
TOTAL WASTE QUANTITY		~~0~~	~~1~~	~~2~~	~~3~~	~~5~~		~~15~~
WASTE INCOMPATIBILITY		~~0~~	~~1~~	~~2~~	~~3~~	~~5~~		~~15~~
USE OF LINERS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF GAS COLLECTION SYSTEMS		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS	Good	[✓ 0]	1	2	3	2	0	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 8.						SUBTOTALS	0	66
PERCENTAGE OF MISSING AND ASSUMED VALUES = 37.5 %.						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		0

NUMBER OF MISSING AND ASSUMED VALUES = 6 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 19.35 %

TOTAL FACTOR SCORE 195

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 437

OVERALL SCORE 45
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

TABLE 26

JRB

NAME OF SITE LANDFILL #3; FACILITY K025.1 WASTE

WASTE CHARACTERISTICS								
TOXICITY	3 Constituents: Sax rating of 3; 1 sax rating of 2	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE		0	1	[✓ 2]	3	5	10	15
IGNITABILITY		0	1	[✓ 2]	3	3	6	9
REACTIVITY		0	1	2	[✓ 3]	3	9	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		[✓ 0]	1	2	3	4	0	12
VOLATILITY		~~0~~	~~1~~	~~2~~	~~3~~	~~4~~		~~12~~
PHYSICAL STATE		0	1	[✓ 2]	3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS							4	20
NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 9.						**SUBTOTALS**	58	128
PERCENTAGE OF MISSING AND ASSUMED VALUES = 11.1 %.						**SUBSCORE** (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		45
WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Fence, guard	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY		[✓ 0]	1	2	3	7	0	21
TOTAL WASTE QUANTITY		~~0~~	~~1~~	~~2~~	~~3~~	~~5~~		~~15~~
WASTE INCOMPATIBILITY		~~0~~	~~1~~	~~2~~	~~3~~	~~5~~		~~15~~
USE OF LINERS	None	0	1	2	[✓ 3]	3	9	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	[✓ 2]	3	3	6	9
USE OF GAS COLLECTION SYSTEMS		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS		0	1	2	3	2	2	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 8.						**SUBTOTALS**	17	66
PERCENTAGE OF MISSING AND ASSUMED VALUES = 37.5 %.						**SUBSCORE** (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		26

NUMBER OF MISSING AND ASSUMED VALUES = 7 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 22.58 %

TOTAL FACTOR SCORE 183

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 419

OVERALL SCORE 44
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

TABLE 27

WASTE K025.1 JRB SCHEME SCORES WITH AND WITHOUT WASTE-CHARACTERISTIC DATA INCORPORATED

Landfill	Site Management Score Percentage of Missing Values	Site Management Score Score	Score Incorporating Waste-Specific Data Percentage of Missing Values	Score Incorporating Waste-Specific Data Score
#1	5.26	63	12.9	55
#2	10.53	47	19.35	45
#3	15.79	46	22.58	44

The waste-specific data are provided in Tables 28-30 and 31-33 for two other case study wastes: wastewater treatment sludge from the production of toxaphene (K041.1); and wastewater treatment sludge from the production of titanium dioxide pigment using chromium-bearing ores by the chloride process (K074.1-generating and disposing a delisted waste) respectively.

Table 34 summarizes the hazard scores of the three wastes as they are disposed at the three land disposal sites according to the JRB hazard ranking.

TABLE 34

SUMMARY OF JRB SCORES FOR THREE WASTES AT THREE SITES

Landfill	Waste K025.1 Percentage of Missing Values	Waste K025.1 Score	Waste K041.1 Percentage of Missing Values	Waste K041.1 Score	Waste K074.1 Percentage of Missing Values	Waste K074.1 Score
#1	12.9	55	3.2	51	3.2	56
#2	19.35	45	9.7	41	9.7	49
#3	22.58	44	12.9	40	12.9	48

TABLE 28

JRB

NAME OF SITE LANDFILL #1, FACILITY: K041 WASTE

WASTE CHARACTERISTICS								
TOXICITY	Toxaphene: Sax Rating 3	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Polycyclic	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY	Soluble	0	1	[✓ 2]	3	4	8	12
VOLATILITY	0.2 - 0.4 mm Hg	[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Carcinogenic and Bioaccumulative						6	20
						SUBTOTALS	54	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		39

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	470 Tons	0	[✓ 1]	2	3	7	7	21
TOTAL WASTE QUANTITY	0.35 acre feet	[✓ 0]	1	2	3	5	0	15
WASTE INCOMPATIBILITY	Segregated	[✓ 0]	1	2	3	5	0	15
USE OF LINERS	Bentonite	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	2	[✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0]	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS	None	0	1	2	[✓ 3]	2	6	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	22	102
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		22

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 3.2 %

TOTAL FACTOR SCORE 254

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 497

OVERALL SCORE 51
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE LANDFILL #2, FACILITY: K041.1 WASTE ......

WASTE CHARACTERISTICS

TOXICITY	Toxaphene (Sax Rating: 3)	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Polycyclic	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY	Soluble	0	1	[✓ 2]	3	4	8	12
VOLATILITY	0.2 - 0.4 mm Hg	[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Carcinogenic & Bioaccumulative						6	20
						SUBTOTALS	54	140
						SUBTOTAL SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		39

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES

SITE SECURITY	Locked fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	470 tons	0	[✓ 1]	2	3	7	7	21
TOTAL WASTE QUANTITY	0.35 acre feet	[✓ 0]	1	2	3	5	0	15
WASTE INCOMPATIBILITY	Segregated	[✓ 0]	1	2	3	5	0	15
USE OF LINERS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF GAS COLLECTION SYSTEMS		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS	Good	[✓ 0]	1	2	3	2	0	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	7	96
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		7

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 9.7 %

TOTAL FACTOR SCORE 198

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 479

OVERALL SCORE 41
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

TABLE 30

NAME OF SITE LANDFILL #3: FACILITY K041.1 WASTE

WASTE CHARACTERISTICS								
TOXICITY	Toxaphene (Sax Rating: 3)	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Polycyclic	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY	Soluble	0	1	[✓ 2]	3	4	8	12
VOLATILITY	0.2 - 0.4 mm hg	[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Carcinogenic and Bioaccumulative						6	20
						SUBTOTALS	54	140
						SUBSCORF (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		39

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Fence, guard	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	470 tons	0	[✓ 1]	2	3	7	7	21
TOTAL WASTE QUANTITY	0.35 acre ft.	[✓ 0]	1	2	3	5	0	15
WASTE INCOMPATIBILITY	Segregated	[✓ 0]	1	2	3	5	0	15
USE OF LINERS	None	0	1	2	[✓ 3]	3	9	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	[✓ 2]	3	3	6	9
USE OF GAS COLLECTION SYSTEMS		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS		0	[✓ 1]	2	3	2	2	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	24	96
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		25

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

NUMBER OF MISSING AND ASSUMED VALUES = 4 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.90 %

TOTAL FACTOR SCORE 186

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 461

OVERALL SCORE 40
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE LANDFILL #1: FACILITY K074.1 WASTE

WASTE CHARACTERISTICS								
TOXICITY	Chromium Compounds	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Metals	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS	PH 2.5-4	0	1	[✓ 2]	3	3	6	9
SOLUBILITY		0	1	[✓ 2]	3	4	8	12
VOLATILITY		0	[✓ 1]	2	3	4	4	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Bioaccumulative						2	20
						SUBTOTALS	60	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		43

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	3600 Tons	0	1	2	[✓ 3]	7	21	21
TOTAL WASTE QUANTITY		0	1	2	[✓ 3]	5	15	15
WASTE INCOMPATIBILITY		[✓ 0]	1	2	3	5	0	15
USE OF LINERS	Bentonite	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	2	[✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0]	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS	None	0	1	2	[✓ 3]	2	6	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	51	102
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		41

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 3.2 %

TOTAL FACTOR SCORE 289

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 497

OVERALL SCORE 58

(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

JRB

NAME OF SITE LANDFILL #2: FACILITY K074.1 Waste

WASTE CHARACTERISTICS								
TOXICITY	Chromium Compounds	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Metals	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS	PH 2.5-4	0	1	[✓ 2]	3	3	6	9
SOLUBILITY		0	1	[✓ 2]	3	4	8	12
VOLATILITY		0	[✓ 1]	2	3	4	4	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Bioaccumulative						2	20

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

SUBTOTALS 60 140

SUBSCORE 43
(FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked Fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	3600 Tons	0	1	2	[✓ 3]	7	21	21
TOTAL WASTE QUANTITY		0	1	2	[✓ 3]	5	15	15
WASTE INCOMPATIBILITY		[✓ 0]	1	2	3	5	0	15
USE OF LINERS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF GAS COLLECTION SYSTEMS		0	1	2	3	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS	Good	[✓ 0]	1	2	3	2	0	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

SUBTOTALS 36 96

SUBSCORE 38
(FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 9.7 %

TOTAL FACTOR SCORE 2 33

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 479

OVERALL SCORE 49
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE LANDFILL #3; FACILITY K074.1 Waste **JRB**

WASTE CHARACTERISTICS

TOXICITY	Chromium Compounds	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Metals	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS	PH 2.5-4	0	1	[✓ 2]	3	3	6	9
SOLUBILITY		0	1	[✓ 2]	3	4	8	12
VOLATILITY		0	[✓ 1]	2	3	4	4	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Bioaccumulative						2	20
						SUBTOTALS	60	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		43

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES

SITE SECURITY	Fence, guard	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	3600	0	1	2	[✓ 3]	7	21	21
TOTAL WASTE QUANTITY		0	1	2	[✓ 3]	5	15	15
WASTE INCOMPATIBILITY		[✓ 0]	1	2	3	5	0	15
USE OF LINERS	None	0	1	2	[✓ 3]	3	9	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	[✓ 2]	3	3	6	9
USE OF GAS COLLECTION SYSTEMS		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS		0	[✓ 1]	2	3	2	2	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	53	96
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		55

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

NUMBER OF MISSING AND ASSUMED VALUES = 4 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.9 %

TOTAL FACTOR SCORE 221

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 461

OVERALL SCORE 48
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

A comparison of the K074 waste (delisted by EPA) and the K041 (toxaphene) waste point out some interesting dimensions of the analysis. In the case of all three landfills, the K074 waste receives a higher hazard rating than the toxaphene waste. The toxaphene waste is a high toxicity/low volume waste. The K074 waste was delisted as low toxicity/high volume waste. The results can be explained in part by the fact that this scheme makes no provision for a consideration of the concentration of various constituents. The K074.1 facility representative stated that hexavalent chromium was present in the waste at a concentration of less than 1 ppm and that trivalent chromium was reported to be in the 30 ppm range. While trivalent chromium is considered to be relatively non-toxic, hexavalent chromium is known to be highly toxic and carcinogenic. Another factor affecting the scores is the waste quantity; the K074 is generated in much greater volume than the toxaphene waste.

These waste quantity/constituent concentration relationships, so fundamental to the computation of the Michigan and Washington schemes, seem to explain the unanticipated rating of K074 as more hazardous than K041 by the JRB scheme. It should be reemphasized that the JRB scheme was originally designed to rank sites for remedial action priority, not to assess degree of hazard for regulatory purposes.

The JRB scheme does rank the Landfill #1 consistently as having the greatest hazard potential, #2 having the next greatest hazard potential, and #3 as having the least hazard potential in the cases employing any of the three waste types. Ideally these site characteristics could be linked to waste characteristics for overall hazard evaluation. For example, a waste stream with extremely soluble, persistent, and toxic wastes disposed in a fill overlying an aquifer in an area with a high net precipitation presents a unique hazard configuration which might be better evaluated by a system that assigns multipliers to specific groups of parameters. Under such a system solubility, net precipitation and depth to groundwater would be considered a evaluative unit. The score would be elevated by a prescribed multiplier when linked to a unit considering carcinogenicity and persistence.

A defensible degree of hazard scheme, applied on a nationwide basis must allow for the interaction of waste and site characteristics in addition to incorporating separate measures of waste properties and environmental/management suitability.

SUMMARY

The preceding case study applications of the degree of hazard schemes have demonstrated the mechanics and caveats inherent in scheme application. These case studies demonstrate various approaches to identifying, quantifying and ranking elements which contribute to hazard potential, and they exemplify some of the uncertainties inherent in these ranking procedures. Many of these uncertainties relate to the extant data base and some relate to the prescribed weighting of various scheme components. While none of these procedures for hazard assessment appears directly applicable to national hazardous waste management regulation, each provides a unique avenue to guide national degree of hazard scheme development.

CHAPTER 4

SUMMARY OF RESULTS OF CLASSIFICATION BY DEGREE OF HAZARD FOR SELECTED INDUSTRIAL WASTE STREAMS

WASHINGTON AND MICHIGAN SCHEME RESULTS

Constituent Ratings

Representatives of 14 industrial plants generating eight of the nine selected waste streams[1] participated in the telephone survey of facility-specific waste generation and disposal practices. For each waste stream, toxic constituents were characterized according to both the Michigan and Washington degree of hazard schemes. Table 35 summarizes the toxicity categorizations for constituents of the nine waste streams according to both the Washington and Michigan classifications. This table presents the classifications according to the State agencies as well as according to Engineering-Science's application of the schemes. Table 36 presents the ES' rationale for assigning the respective scores to the individual waste constituents according to the Washington scheme. Table 37 presents ES' constituent scores and sub-scores according to the Michigan system.

Of the 31 constituents in the case study waste streams, the Michigan Department of Natural Resources published scores for 14 (about 45 percent) and the Washington State Department of Ecology scored 21 (about 68 percent). Of the constituents scored by both the Michigan DNR and Engineering-Science, different scores were assigned in four instances (or for approximately 28 percent of the constituents scored) as presented below:

Waste Stream	Constituent	Michigan DNR Assigned Score	ES Assigned Score
K073	Chloroform	B	A
K073	Carbon tetrachloride	B	A
K073	1,2-dichloroethylene	D	B
K073	1,1,2,2-tetrachloroethane	B	A

Of the constituents scored by both the Washington Department of Ecology and Engineering-Science, different scores were assigned in two instances (or for approximately 9.5 percent of the constituents scored) as presented below:

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[1] Light and heavy ends from the distillation of acetaldehyde in production of acetic anhydride was the one waste stream for which facility-specific data were unavailable.

TABLE 35

DEGREE OF HAZARD TOXICITY CATEGORIES OF CASE STUDY WASTE CONSTITUENTS

		Michigan		Washington	
		Michigan Scheme Category		Washington Scheme Category	
Waste Stream	Constituent[1]	As Reported By Michigan DNR	As Calculated By ES	As Reported By Washington Dept of Ecology	As Calculated By ES
K071	Mercury*	-	A	-	X
K060	Arsenic*	-	A	B	B
K060	Arsenic Trioxide	-	A	B	B
K060	Arsenic Pentoxide	-	A	B	B
K060	Naphthalene	B	B	B	B
K060	Cyanide*	-	B	A	X
K060	Phenol	B	B	C	C
F009	Sodium Cyanide	-	B	-	B
F009	Potassium Cyanide	-	A	A	B
K013	Acetonitrile	-	B	C	C
K013	Acrylonitrile	B	B	C	C
K013	Hydrocyanic Acid	-	B	A	A
Heavy and Light** Ends	Methyl Acetate	-	--††	-	--††
Heavy and Light** Ends	Acetone	-	--††	D	D
Heavy and Light** Ends	Ethylidene diacetate	-	D	-	--††
Heavy and Light* Ends	Ethyl acetate	-	B	D	D

TABLE 35

(continued)

		Michigan		Washington	
		Michigan Scheme Category		Washington Scheme Category	
Waste Stream	Constituent[1]	As Reported By Michigan DNR	As Calculated By ES	As Reported By Washington Dept of Ecology	As Calculated By ES
K073	Chloroform	B	A	C	C
K073	Hexachloroethane	B	B	-	B
K073	Carbon tetrachloride	B	A	C	C
K073	1,1,2- Trichloroethane	B	B	C	C
K073	1,1,1- Trichloroethane	B	B	C	C
K073	Tetrachloroethylene	B	B	C	C
K073	1,2-Dichloroethylene	D†	B	D	D
K073	1,1-Dichloroethylene	B	B	C	C
K073	1,1,2,2-tetrachloroethane	B	A	-	C
K041	Toxaphene*	A	A	X	X
K025	meta-Dinitrobenzene	-	B	-	B
K025	2,4-Dinitrotoluene	B	B	C	C
K074	Chromium* (Trivalent $CrCl_3$)	-	B	-	D
K074	Chromium* (Trivalent Cr_2O_3)	-	B	-	D
K074	Chromium* (hexavalent)	-	B	-	C

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[1] As identified in EPA Background Document, RCRA, Subtitle C - Identification and Listing of Hazardous Wastes (Phase 1B), Washington, D.C., August 1979.

* May be classified as EP Toxic according to either scheme depending upon concentration.

**Light and heavy ends from the distillation of acetaldehyde in the production of acetic acid.

† Note: Characterization is specifically for the trans isomer.

††Insufficient data to determine category.

TABLE 36

SCORES FOR INDIVIDUAL CONSTITUENTS OF THE CASE STUDY WASTES ACCORDING TO THE WASHINGTON SCORING SYSTEM

Waste	Constituent	Basis for Toxicity Assessment	Category
F009	Sodium Cyanide	Oral Rat LD_{50}: 6 mg/kg	B
	Potassium Cyanide	Oral Rat LD_{50}: 10 mg/kg	B
K013	Acetonitrile	Dermal Rabbit LD_{50}: 980 mg/kg	C
	Acrylonitrile	Oral Rat LD_{50}: 82 mg/kg	C
	Hydrocyanic Acid	TLm_{96} <1.0 ppm*	A
K025	meta-Dinitrobenzene	Oral Rat LD_{50}: 30 mg/kg	B
	2,4-dinitrotoluene	Oral Rat LD_{50}: 268 mg/kg	C
K041	Toxaphene	Aquatic LC_{50}: .028 ppm	X
K060	Cyanide	Aquatic LC_{50}: .052 ppm	X
	Naphthalene	Aquatic LC_{50}: 2.4 ppm	B
	Phenolic Compounds	Oral Rat LD_{50} 414 mg/kg	C
	Arsenic	Oral Rat LD_{50} 15 mg/kg	B
K071	Mercury	Aquatic LC_{50}: .005 ppm	X
K073	Chloroform	Aquatic LC_{50}: 18 ppm	C
	Hexachloroethane	Aquatic LC_{50}: 2.4 ppm	B
	Carbon tetrachloride	Aquatic LC_{50}: 27.3 ppm	C
	1,1,2-trichloroethane	Oral rat LD_{50}: 100 mg/kg	C
	1,1,1-trichloroethane	Aquatic LC_{50}: 69.7 ppm	C
	Tetrachloroethylene	Aquatic LC_{50}: 12.9 ppm	C
	1,2,-dichloroethylene	Oral Rat LD_{50} 770 mg/kg	D
	1,1-dichloroethylene	Oral Rat LD_{50} 200 mg/kg	C
	1,1,2,2-tetrachloroethane	Oral Rat LD_{50} 200 mg/kg	C
K074	Cr^{+3}	Oral Rat LD_{50} 1870 mg/kg	D
	Cr^{+6}	Aquatic LC_{50}: 17.6 mg/l	C

*This value is conservative because it represents the median threshold limit rather than the LC_{50} the scheme requires. No aquatic LC_{50} data were available on which to base a determination.

TABLE 37

SCORES FOR INDIVIDUAL CONSTITUENTS OF THE CASE STUDY WASTES ACCORDING TO THE MICHIGAN SCORING SYSTEM

Waste	Constituent	Scores								
		Acute Toxicity	Carcinogenicity	Hereditary Mutagenicity	Teratogenicity	Persistence	Bioaccumulativity	Other Adverse Effects	Total Score	Toxicity Category
F009	Sodium Cyanide	7	-	-	-	0	0	3	10	B
	Potassium Cyanide	7	-	7	-	0	0	3	17	A
K013	Acetonitrile	1	0	-	7	-	-	-	8	B
	Acrylonitrile	5	7	3	5	0	0	5	25	B
	Hydrocyanic Acid	7	-	-	-	-	0	-	7	B
K025	Meta-dinitrobenzene	5	-	3	-	0	0	3	11	B
	2,4-dinitrotoluene	3	7	5	-	24	0	5	22	B
K041	Toxaphene	7	7	-	-	-	7	7	28	A
K060	Cyanide	7	-	-	-	-	0	5	12	B
	Naphthalene	5	-	-	-	-	0	5	10	B
	Phenolic Compounds	7	-	-	-	0	-	5	12	B
	Arsenic	5	7	-	7	-	3	5	27	A
K071	Mercury	7	-	7	7	-	7	5	33	A
K073	Chloroform	3	7	-	7	4	0	5	26	A
	Hexachloroethane	1	7	0	0	4	1	5	18	B
	Carbon tetrachloride	3	7	-	7	4	0	5	26	A
	1,1,2-trichloroethane	3	7	-	-	-	-	5	15	B
	1,1,1-trichloroethane	3	7	-	-	1	0	3	14	B
	Tetrachloroethylene	3	7	3	-	1	0	3	17	B
	1,2-dichloroethylene	1	-	3	-	-	-	3	7	B
	1,1-dichloroethylene	3	7	3	0	0	0	3	16	B
	1,1,2,2-tetrachloroethane	3	7	3	7	4	0	5	29	A
K074	Cr^{+3}	5	5	0	-	4	0	3 or 5	17 or 19	B
	Cr^{+6}	3	7	5	-	4	0	3 or 5	22 or 24	B

Possible Scores for Individual Factors:

Acute Toxicity - 0,1,3,5,7
Carcinogenicity - 0,1,3,5,7
Hereditary Mutagenicity - 0,3,5,7
Teratogenicity - 0,5,7

Persistence - -2, -1,0,1,2,3,4
Bioaccumulativity - 0,1,3,5,7
Other Adverse Effects - 0,1,3,5,7

Waste Stream	Constituent	Washington Dept. of Ecology Assigned Score	ES Assigned Score
K060	Cyanide	A	X
F009	Potassium cyanide	A	B

These discrepancies may reflect the data bases available to the various groups for the calculation of hazard scores. They may, particularly in the case of the Michigan scheme, reflect differences in the interpretation of data relative to scheme parameters.

As is demonstrated by the ES-assigned values presented in Table 35, the two schemes rate constituents differently in that the rankings do not correspond even in terms of their relative variability. For example, in five cases the Michigan and Washington ratings, as calculated by ES, are the same letter; in 13 cases the Washington value is one rank less hazardous than the Michigan value; in six cases the Washington value is two letters less hazardous; in three cases the Washington value is one rank more hazardous than by the Michigan scheme; and in one case the Washington score is two levels more hazardous than the Michigan value.

For example, in the case of waste stream K013, two constituents, acetonitrile and acrylonitrile, receive higher scores by the Michigan scheme than they do by the Washington scheme. By contrast, the remaining constituent of waste stream K013, hydrocyanic acid, receives a higher score by the Washington system than it does by the Michigan system. Thus although it is recognized that these schemes do not rate constituents on the same scale of hazardousness (the Washington scheme ranks chemicals from "X" to "D", and the Michigan scheme rankings range from "A" to "D") it is nevertheless interesting that their applications to the same set of chemicals does not result in even a consistent relative ranking.

These apparent discrepancies illustrate the fact that the Michigan system factors carcinogenicity and teratogenicity (properties of acrylonitrile and acetonitrile, respectively) with the same weight that it factors toxicity. Thus each of the three constituents of K013 scores a seven in a different rating category. Of these constituents, hydrocyanic acid is the only constituent that is characterized as having high acute toxicity. Since the Washington scheme only considers toxicity in this rating process, hydrocyanic acid gets a high toxicity score (A) and the other constituents, although either carcinogenic or teratogenic, rate lower scores (C).

However, assignment of toxicity scores is only a preliminary step in hazard assessment. The constituent concentrations and waste quantities must also be evaluated to complete the hazard determination.

Quantity and Concentration Considerations

Table 38 presents the constituent concentrations and waste quantities generated by the 14 facilities in the study sample. The constituents displayed in Table 38 are those for which the wastes were listed by EPA, and do not, except in the case of K025, include additional toxic constituents reported by facility personnel.[1]

Table 39 presents the final waste designation by the two systems based on the quantity/concentration analysis. Both F009 wastes are listed in Table 38 as unregulated by both the Michigan and Washington schemes. This status results from the factoring of the extremely low concentrations of the constituents of concern. In actuality these wastes would be regulated by the Michigan scheme because the management designation process involves the inclusion of those wastes listed by EPA as managed under Michigan Act 64. Thus since F009 is EPA-listed, it would be regulated by the Michigan program even though it would be unregulated under the toxicity/quantity/concentration formula.

Another waste which would be unregulated under both systems according to the formula application is K041.2, one of the two toxaphene bearing wastes. Toxaphene rates the highest toxicity ranking of the entire constituent sample. The fact that it is present in this waste at a concentration of only 1.5 ppb or 1.5×10^{-7} percent exempts the stream from regulation even though it is generated in great volume (20,736,000 gallons annually or about 6.54×10^{6} kg/mo). The other toxaphene waste-generating facility, K041.1, generates waste at a much lower quantity (200 tons annually or about 15,120 kg/mo) but at a much higher concentration (between 0.5 and 1 percent by weight) and would be regulated under both state schemes.

K073.1 would be unregulated under either of the two state systems both because it is generated in small amounts (1.1 kg/mo or about 30 pounds annually) and because the constituents are present in very low concentrations (on the order of parts per billion).

The K074.1 waste, already delisted by EPA, would be unregulated by the Michigan system and regulated under the Washington system in the dangerous waste category. EPA's determination was based on the assumption that the chromium present in the waste is primarily in the trivalent state and that the amount of hexavalent chromium is negligible.

The data pertaining to the K071 wastes were provided in the form of mercury concentration ranges in addition to average concentration values. At the upper end of the ranges the waste would be regulated

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[1] This decision was based on constraints related to the project timetable. The project team gathered the requisite toxicity data for constituents listed in the EPA background documents for the specific waste streams while waiting for industry representatives to respond to requests for information.

TABLE 38

WASTE QUANTITIES AND CONSTITUENT CONCENTRATIONS EMPLOYED IN HAZARD ASSESSMENTS

Facility Code	Constituent Concentrations		Waste Quantity	Disposal Method
F009.1	Sodium Cyanide Potassium Cyanide	.008 mg/l	~440 kg/mo (disposed quarterly)	Metal and cyanide reduction, sludge dewatering through centrifugation, disposal in commercial landfill.
F009.2	Sodium Cyanide Potassium Cyanide	.060 mg/l	~1,080,000 kg/mo	Effluent goes to two sequential settling basins, then to POTW.
K013.1	Acetonitrile Acrylonitrile Hydrocyanic Acid	10-100 ppm 10-50 ppm 50-300 ppm	~30.0x10^6 kg/mo	Wastewater is treated and discharged to municipal sewer system. Some materials are are incinerated on site.
K013.2	Acetonitrile Acrylonitrile Hydrocyanic Acid	10-50 ppm 10-50 ppm 50-200 ppm	~27.2x10^6 kg/mo	Waste water is combined with K011 and K014 waste and is clarified, stored, filtered and disposed in waste disposal cells.
K025.1	Meta-dinitrobenzene 2,4-dinitrotoluene Benzene Nitrobenzene Aniline	0.1-0.2% <0.01% 0.01% 96-98 1-1.5%	~625 kg/mo	Wastes are stored in tanks and then incinerated.
K041.1	Toxaphene	0.5-1%	~15,000 kg/mo	Wastewater is neutralized and dewatered. The resulting sludge is disposed in landfill.
K041.2	Toxaphene	1.5 ppb	~6.5x10^6 kg/mo	Wastewater is stored on site in unlined pond, treated by activated carbon filtration, and discharged to waterway.

TABLE 38 (Continued)

WASTE QUANTITIES AND CONSTITUENT CONCENTRATIONS EMPLOYED IN HAZARD ASSESSMENTS

Facility Code	Constituent Concentrations		Waste Quantity	Disposal Method
K060.1	Cyanide	55 mg/l	~30,000 kg/mo	Waste is landfilled on-site.
	Naphthalene	0		
	Phenolic Compounds	0		
	Arsenic	0		
K060.2	Cyanide	0.58 ppm	~277,000 kg/mo	Waste is stored on site under roof and on cement floor.
	Napthalene	<3.8 ppm		
	Phenolic Compounds	35.6 ppm		
	Arsenic	21.0 ppm		
K071.1	Mercury	Avg. 70 ppm Range 7-230 ppm	~400,000 kg/mo	Sludge is dewatered and landfilled on-site.
K071.2	Mercury	10-60 ppm	~830,000 kg/mo	Sludge is dewatered and landfilled.
K071.3	Mercury	10-60 ppm	~170,000 kg/mo	Sludge is dewatered and landfilled.
K073.1	Chloroform	44 ppb	~1.1 kg/mo	Waste is piped to surface impoundment/solar evaporation pond.
	Hexachloroethane	6 ppb		
	Carbon tetrachloride	109 ppb		
	1,1,2-trichloroethane	0		
	1,1,1-trichloroethane	0		
	Tetrachloroethylene	15 ppb		
	1,2-dichloroethylene	11 ppb		
	1,1-dichloroethylene	11 ppb		
	1,1,2,2-tetrachloroethane	0		
K074.1	Trivalent chromium	30 ppm	~273,000 kg/mo	Sludge is kept in a holding pond and once or twice a year titanium and coke are dredged and reclaimed.
	Hexavalent chromium	<1 ppm		

TABLE 39

MANAGEMENT STATUS OF CASE STUDY WASTES
ACCORDING TO TOXICITY HAZARD CATEGORY, QUANTITY AND CONCENTRATION

Facility	Hazard Categories: Washington	Hazard Categories: Michigan	Management Designation: Washington	Management Designation: Michigan
F009.1	2B	1B;1A	Unregulated	Unregulated
F009.2	2B	1B;1A	Unregulated	Unregulated
K013.1	2C;1A	3B	Dangerous Waste	Regulated
K013.2	2C;1A	3B	Dangerous Waste	Regulated
K025.1	1B;2C;2D	1A;2B;1C;1D	Extremely Hazardous Waste	Regulated
K041.1	X	A	Extremely Hazardous	Regulated
K041.2	X	A	Unregulated	Unregulated
K060.1	X	B	Regulated	Regulated
K060.2	1X;2B;1C	1A;3B	Regulated	Regulated
K071.1	X	A	Extremely Hazardous Waste*	Regulated
K071.2	X	A	Extremely Hazardous Waste*	Regulated
K071.3	X	A	Extremely Hazardous Waste*	Regulated
K073.1	1B;7C;1D	3A;6B	Unregulated	Unregulated
K074.1	1C;2D	3B	Dangerous Waste	Unregulated

*Mercury concentration ranges were provided for each of these facilities. At the upper end of the range the waste would be designated extremely hazardous. At the lower end of the range the wastes are designated as dangerous.

by both state systems. At the lower end of the ranges the waste would be exempt from the extremely hazardous category in the Washington scheme, but would be regulated as a dangerous waste.

LOGISTICAL DIFFICULTIES INHERENT IN THE APPLICATION OF THE MICHIGAN AND WASHINGTON CLASSIFICATION SCHEMES

The major problems inherent in the application of the Michigan and Washington classification schemes relate to the extant toxicological data base. Because these problems are likely to characterize any national effort to develop and apply degree of hazard schemes, they warrant serious consideration. These problems include:

- Data interpretability;
- Data variability; and
- Data availability.

The following discussion addresses the influence of these factors on the application of the Michigan and Washington schemes to the case study waste streams.

Data Interpretability

One notable problem inherent in the classification of waste constitutent toxicity lies in the translation of information presented in the literature, (or in literature summaries such as RTECS) to the categories identified in the schemes. The determination of the "Other Adverse Effects" scores required for the Michigan scheme toxicity rating provides a good example of this problem. These scores require information relative to the reversibility or irreversibility of any noted chronic effect, as well as data concerning the chemical dose at which these effects are observed. While the literature may describe an adverse effect which might reasonably be described as a chronic effect, categorizing the effect according to the criteria provided (reversible or irrreversible) may pose a difficult interpretative problem for the evaluator.

The categorization of constituent carcinogenicity, also required by the Michigan toxicity rating, offers another example of this problem. The literature may relate the results of a particular carcinogenicity bioassay; describing in detail the perceived growth abnormalities associated with the assay. The evaluator must then ascertain if these results provide adequate evidence to justify labeling the chemical as "a potential animal carcinogen". Even a board of toxicologists might disagree among themselves as to which determination to make in a variety of routinely encountered circumstances.

Another data interpretation issue concerns specification of the chemical form of the constituents. The specific isomer of a constituent present in a waste stream may be either unspecified or unknown. The different geometric isomers may have significantly different toxic properties, as is the case with cis- and trans- 1,2-dichlorethylene (i.e., cis-1,2-dichloroethlyene: cat inhalation LCLO: 20,000 mg/m^3/6 H vs. trans-1,2-dichloroethylene: cat inhalation LCLO: 43,000 mg/m^3/6 H)[1]. The literature also reports different results for toxicity measurements for the sodium and potassium salts of cyanide.

Any national degree of hazard scheme addressing toxicity will be most efficiently applied if it is based on a standardized set of toxicological information provided for the scheme, as well as a standardized, nationally accessible data base.

Data Variability

The ranges of values for categorizing toxicity for a particular chemical were in some instances narrower than the ranges for that parameter as documented in the literature. Thus, the data source or data point an evaluator selects for the classification of a chemical can affect the ultimate categorization. Reported values for different toxicity tests may result in two or more possible toxicity categories as discussed in Chapter 3. The influence of data variability in the toxicological data base on degree of hazard assessments should be considered at the outset of efforts to design a national hazard assessment scheme.

Data Availability

Data availability is a chronic problem in the design and implementation of environmental regulations. Degree of hazard is no exception. Each of the two State degree of hazard schemes evaluated in the study required more data than existed in the literature for some waste stream constituents. The categorizations of several chemicals were based on only one or two toxicological data points, while others were evaluated on a much firmer data base. In order to address this problem, a national degree of hazard scheme may require that particular laboratory tests be conducted to evaluate chemicals which have not previously been studied sufficiently.

JRB SCHEME RESULTS

The project team developed site-specific data for three of the case study facilities. For each of these facilities, designated as facility #1, #2, and #3, the constant site-specific data were characterized according to the JRB scheme requirements. All 14 of the facility wastes profiled were evaluated in terms of their suitability for waste disposal at each of the three sites. See Chapter 3 for a discussion of which of the JRB rating factors were considered variable by waste stream being evaluated and which rating factors are constant for the facility being evaluated.

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[1] NIOSH, RTECS U.S. GPO, Washington, D.C., 1980.

The scores for each waste stream evaluated in the context of each specific waste disposal setting are provided in Table 40. The actual score sheets from which these assessments were derived are presented in Appendix C.

The JRB scheme application to the 14 waste streams at the three different sites support the contention that the Landfill #1 site poses a higher hazard than that of either Landfill #2 or #3. The primary reason for the elevated scores for Landfill #1 relate to the pathways category. This site is reported to have inadequate runoff control and elevated levels of toxic constituents have been reported following heavy rains. It is located in an area where the water table is very shallow and the soil is sandy. This facility is located approximately 1/8 mile from the nearest drinking water well and the land use/zoning is a mix of agricultural and residential. If remedial action priorities were being assigned for the three sites, site #1 would require priority attention. If environmental risk considerations were factored into exemption determinations this site would score lower relative to site suitability than the other two sites. There were no significant differences noted in the scores for sites #2 and #3 although facility #3 consistently received a better score than facility #2.

The scores for the three landfills did not rank waste stream relative toxicity as might have been expected. The waste receiving the highest score for all three landfills was that of facility K013.1. This waste ranks in the middle of the sample relative to toxicity, but its reactivity, volatility, and solubility raised its scores in the waste characteristics category. Waste K074.1, the least toxic waste, according to the Washington scheme and the U.S. EPA, ranked third most hazardous in the combined score for the three landfills. Its low toxicity rating by the Michigan scheme resulted largely from a lack of data for various toxicity measures required to compute the degree of hazard. This waste is persistent, corrosive, soluble, and bioaccumulative, and scores a high Sax rating. The Sax rating factored into waste evaluation by the JRB scheme corresponds to the other schemes toxicity values.

The JRB scheme results thus demonstrate the influence of factors related to environmental contamination potential and hazards related to handling procedures on the score for the Waste Characteristics category. This category provides the heaviest weighting for toxicity and radioactivity, but numerous physico/chemical properties, for example, volatility and solubility are also represented in the score. The absence of representation of these properties in the Michigan and Washington schemes, explains why the toxicity ranking of wastes by those schemes were not paralleled in the JRB evaluations.

The JRB scheme provides a ranking for critical variables which have dramatic implications for degree of hazard assessment. As discussed in Chapter 1, a waste poses no hazard to public health until it is released to the environment whereupon the hazard becomes a function of migration rates, persistence, toxicity and proximity to drinking water supplies or other conduits.

TABLE 40

WASTE STREAM EVALUATIONS FOR THREE DIFFERENT LANDFILLS[1]

Facility	Facility 1 Percent Missing Values	JRB Score: Facility 1	Facility 2 Percent Missing Values	JRB Score: Facility 2	Facility 3 Percent Missing Values	JRB Score: Facility 3	Combined Scores
Independent of waste stream	5.26	63	15.79	46	10.53	47	156
F009.1	3.2	49	9.7	39	12.9	39	127
F009.2	3.2	54	9.7	44	12.9	44	192
K013.1	3.2	63	9.7	53	12.9	53	169
K013.2	3.2	58	6.4	48	9.7	47	153
K025.1	12.9	55	19.35	45	22.58	44	143
K041.1	3.2	51	9.7	41	12.9	40	133
K041.2	3.2	56	9.7	46	12.9	45	147
K071.1	3.2	55	9.7	46	12.9	45	146
K071.2	3.2	53	9.7	44	12.9	43	140
K071.3	3.2	54	9.7	45	12.9	43	142
K073.1	3.2	56	9.7	46	12.9	46	148
K074.1	3.2	58	9.7	49	12.9	48	155
K060.1	6.4	53	9.7	42	12.9	42	137
K060.2	3.2	59	6.4	49	9.7	49	158

[1] The numbers represent the total factor score divided by the maximum possible score and multiplied by 100.

The consideration of these kinds of factors is essential to the development of a defensible degree of hazard approach to waste regulation. If the quantity/concentration/toxicity concept were adapted for variable exemption designations, this ratio or formula could then be replotted against a scale of site suitability. The development of such a scale would then parallel the Michigan approach to toxicity rating. The JRB classification scheme provides a foundation for the development of such a rating scale.

CHAPTER 5

REGULATORY CONTEXT OF THE WASHINGTON AND MICHIGAN DEGREE OF HAZARD SCHEMES

The degree of hazard assessments of the Washington and Michigan waste classification procedures are only one element of broader waste evaluation systems. These broader systems are briefly presented in this chapter.

CLASSIFICATION BY TECHNICAL CRITERIA - STATE OF WASHINGTON DEPARTMENT OF ECOLOGY SCHEME

General Description

The classification system developed by the State of Washington Department of Ecology (WDOE) classifies wastes for purposes of characterization and management as Dangerous Wastes (DW) or Extremely Hazardous Wastes (EHW) based on a consideration of the physical/chemical nature of the waste (ignitability, corrosivity, reactivity), as well as the toxicity, persistence, carcinogenicity, and EP toxicity of the waste constituents. The degree of hazard assessment described in Chapters 3 and 4 is only one component of this system. No wastes are categorically exempt by this system, but may be "undesignated" (i.e. not considered hazardous) according to the system. Unlike the Michigan scheme, the Washington regulation specifies all required testing procedures. Table 41 presents a list of the specified analytical methods.

The designation of a waste according to the Washington scheme involves the step-by-step procedure summarized in Figure 7. The degree of hazard level of the scheme is identified in Figure 8. The categories are considered sequentially and once a waste is classified according to a category no further criteria are considered unless the generator has knowledge according to WAC 173-303-070(5) that the waste exhibits the properties of any of the other categories as well.

The following discussion describes the various steps involved in the Washington waste classification process. The quantity exclusions which apply to the various waste categories are presented in Table 42.

Step 1: First it is determined whether the waste is a Discarded Chemical Product according to the list referenced in WAC 173-303-081. If the waste is listed (WAC 173-303-1003) the quantity generated is compared to the quantity exclusion limits in WAC 173-303-081(2). If the waste is listed and produced in sufficient quantities, it is designated as a Dangerous Waste (DW) or an Extremely Hazardous Waste (EHW) according to the designation assigned in WAC 173-303-1003 for that waste.

TABLE 41

ANALYTICAL METHODS SPECIFIED BY THE STATE OF WASHINGTON DEGREE OF HAZARD ASSESSMENT SCHEME

Ignitability

Flash Point - ASTM D-3278-78 or ASTM D-93-79.

Corrosivity

pH - "Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods," from WDOE.

Corrosion - NACE TM-01-69.

EP Toxicity

"Extraction Procedure Test Methods - 1981," from WDOE.

Toxicity

LC_{50} - "Static Acute Fish Toxicity Test," in "Biological Testing."

LD_{50} - "Acute Oral Rat Toxicity Test."

(Both the above in "Biological Testing Methods, Compliance with Hazardous Waste Regulations," DOE 80-12, October 1980).

Persistence

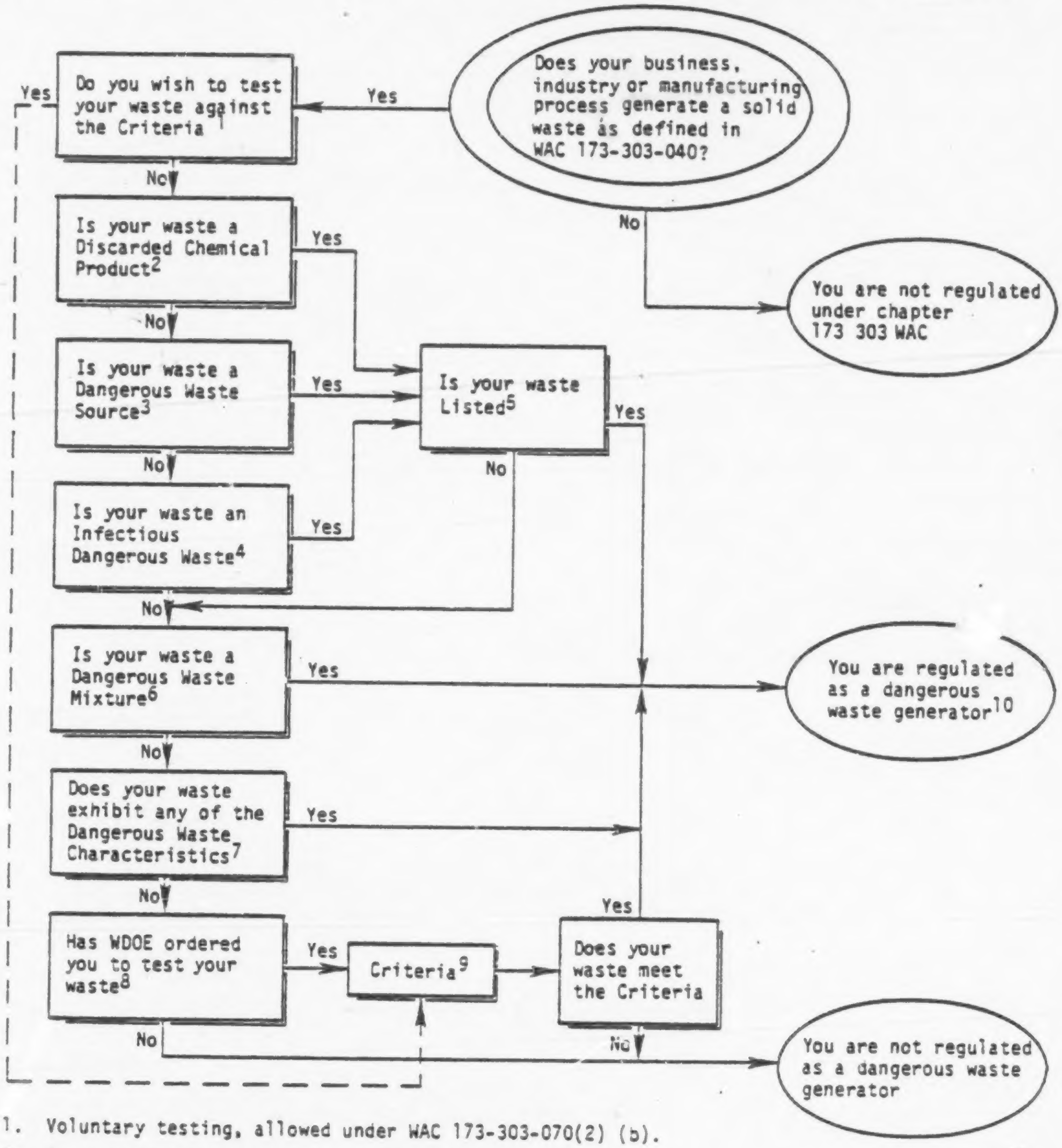
Halogenated hydrocarbons - "Parr Bomb Test for Total Chlorine," from WDOE.

Polycyclic aromatic hydrocarbons - "Analysis for Polynuclear Aromatic Hydrocarbons," from WDOE.

FIGURE 7

Flowchart for Designating Dangerous Wastes

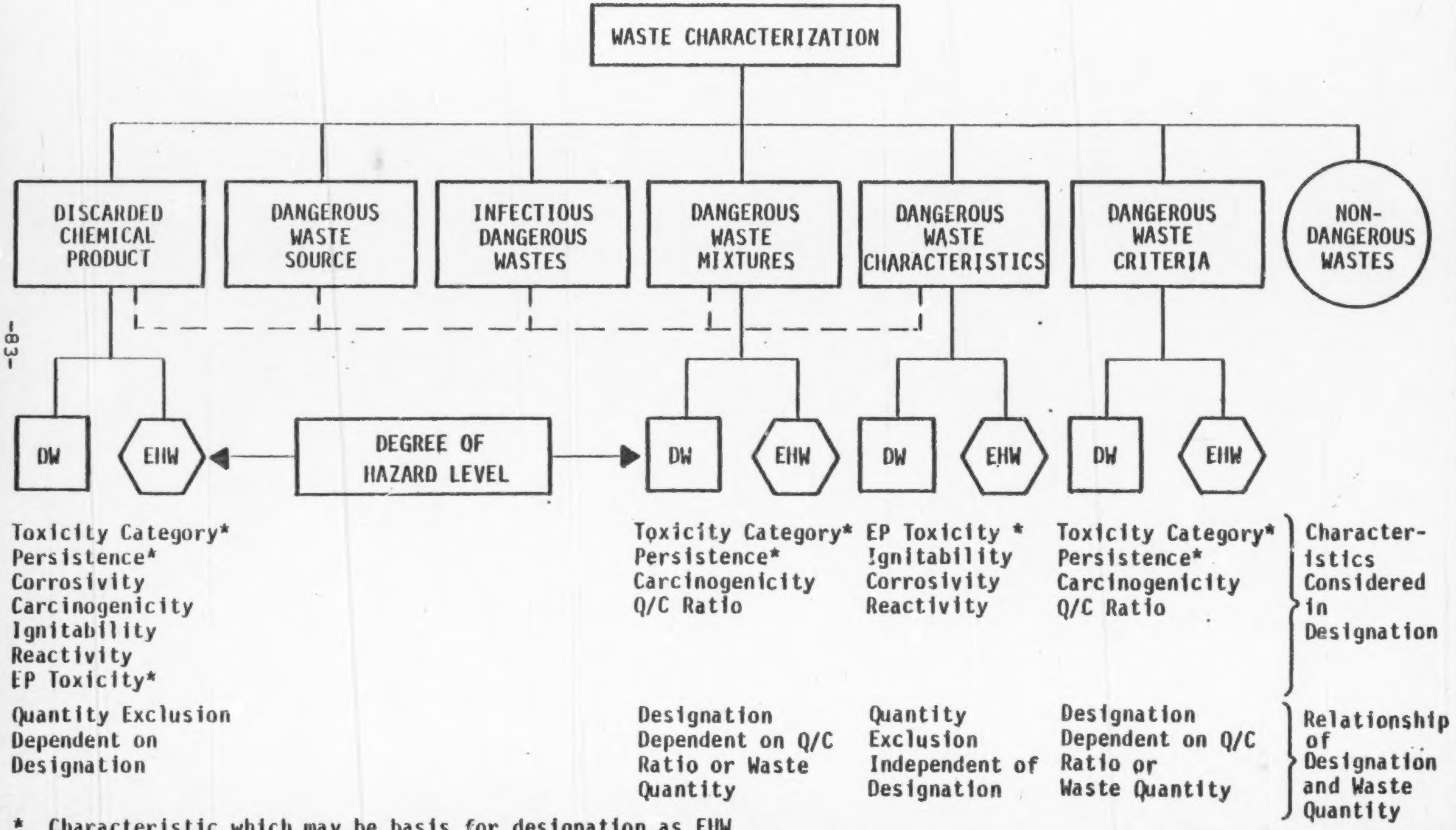
(Adapted from Washington State Regulation WAC 173-303-1001)


Does your business, industry or manufacturing process generate a solid waste as defined in WAC 173-303-040?
Yes
No
You are not regulated under chapter 173 303 WAC
Do you wish to test your waste against the Criteria 1
Yes
No
Is your waste a Discarded Chemical Product2
Yes
No
Is your waste a Dangerous Waste Source3
Yes
No
Is your waste an Infectious Dangerous Waste4
Yes
No
Is your waste Listed5
Yes
No
Is your waste a Dangerous Waste Mixture6
Yes
No
You are regulated as a dangerous waste generator10
Does your waste exhibit any of the Dangerous Waste Characteristics7
Yes
No
Has WDOE ordered you to test your waste8
Yes
No
Criteria9
Does your waste meet the Criteria
Yes
No
You are not regulated as a dangerous waste generator

1. Voluntary testing, allowed under WAC 173-303-070(2) (b).
2. See WAC 173-303-081. Discarded Chemical Products.
3. See WAC 173-303-082. Dangerous Waste Sources.
4. This section, WAC 173-303-083, is reserved, and is not applicable at the publication date of this chapter.
5. The Discarded Chemical Products List appears in WAC 173-303-1003, and the Dangerous Waste Sources List appears in WAC 173-303-1004.
6. See WAC 173-303-084. Dangerous Waste Mixture.
7. See WAC 173-303-090. The Dangerous Waste Characteristics include the properties of ignitability, Corrosivity, Reactivity, and EP Toxicity.
8. Washington Department of Ecology may order testing pursuant to WAC 173-303-070(4) (b).
9. See WAC 173-303-100. Dangerous Waste Criteria.
10. As a dangerous waste generator you must comply with the requirements set forth under WAC 173-303-170.

FIGURE 8

Washington State Degree of Hazard Assessment Scheme


WASTE CHARACTERIZATION
DISCARDED CHEMICAL PRODUCT
DANGEROUS WASTE SOURCE
INFECTIOUS DANGEROUS WASTES
DANGEROUS WASTE MIXTURES
DANGEROUS WASTE CHARACTERISTICS
DANGEROUS WASTE CRITERIA
NON-DANGEROUS WASTES
DW
EHW
DEGREE OF HAZARD LEVEL
DW
EHW
DW
EHW
DW
EHW
Toxicity Category* Persistence* Corrosivity Carcinogenicity Ignitability Reactivity EP Toxicity*
Toxicity Category* Persistence* Carcinogenicity Q/C Ratio
EP Toxicity * Ignitability Corrosivity Reactivity
Toxicity Category* Persistence* Carcinogenicity Q/C Ratio
Characteristics Considered in Designation
Quantity Exclusion Dependent on Designation
Designation Dependent on Q/C Ratio or Waste Quantity
Quantity Exclusion Independent of Designation
Designation Dependent on Q/C Ratio or Waste Quantity
Relationship of Designation and Waste Quantity

* Characteristic which may be basis for designation as EHW
— —Indicates requirement under "Special Knowledge", WAC 173-303-070 (5)

TABLE 42

STATE OF WASHINGTON DEGREE OF HAZARD ASSESSMENT SCHEME

QUANTITY EXCLUSIONS

Category of Waste	Excluded Quantity
Discarded Chemical Products (WAC 173-303-081)	
EHW	≤ 0.51 lbs/wk or batch
DW	≤ 100 lbs/wk or batch
Containers >20 liters	
Innerliners EHW	≤ 5.1 lbs
Residues, soil, water, other debris	≤50.8 lbs
Dangerous Waste Sources (WAC 173-303-082)	≤100 lbs/wk or batch
Dangerous Waste Mixtures (WAC 173-303-084)	Dependent on designation and concentration of waste
Dangerous Waste Mixtures (WAC 173-303-090)	≤ 100 lbs/wk or batch
Dangerous Waste Criteria	
Toxic (WAC 113-303-101)	Dependent on designation and concentration of waste
Persistent (WAC 173-303-102)	≤100 lbs/wk or batch
Carcinogenic (WAC 173-303-103)	≤ 100 lbs/wk or batch

Step 2: If the waste is not designated DW or EHW as Discarded Chemical Product, the next list referenced is Dangerous Waste Sources (WAC 173-303-082). If the waste is listed in WAC 173-303-1004, and is produced in excess of the quantities specified in the rule (Table 42), it is designated DW.

Step 3: If the waste is not from a Dangerous Waste Source, the generator determines whether is is an Infectious Dangerous Waste under WAC 173-303-083.

Step 4: If the waste is not infectious, then it is determined whether the waste is a Dangerous Waste Mixture according to WAC 173-303-084.

This process involves the application of the degree of hazard assessment procedure described in Chapters 3 and 4. First, the known constituents of the waste are listed, together with toxicity data for each from the sources listed in the rule. The presence and concentration of halogenated hydrocarbons (HH), polycyclic aromatic hydrocarbons (PAH), and carcinogenic substances are noted. From the available toxicity data (Aquatic LC_{50}, Oral Rat LD_{50}, Inhalation Rat LC_{50}, and Dermal Rabbit LD_{50}) the Toxic Category for each constituent is determined as described on Table 8. If no data are available, the generator is not required to determine the toxic category.

The next step involves the determination of the concentrations of the toxic constituents. Considering the toxicity category of each constituent and the corresponding concentration, the equivalent concentration [WAC 173-303-084(5)(b)] is calculated as described in Chapter 3.

Next, the quantity of waste generated is determined. From the Toxic Dangerous Waste Mixtures Graph (WAC 173-303-1006), the designation (DW or EHW) is determined (see Figure 1 in Chapter 3).

If the waste contains any halogenated or polycyclic aromatic hydrocarbons, the concentrations are determined separately. The Persistent Dangerous Waste Mixture Graph (WAC 173-303-1007) is consulted and the designation (DW or EHW) is determined in accordance with the relationship presented in Figure 2 in Chapter 3.

If the waste contains a carcinogenic constituent as defined above, the concentration of the carcinogen is determined. If the concentration and the quantity of waste produced are in excess of the amounts specified in WAC 173-303-004(7) and (8), the waste is designated DW.

If the waste is not a Dangerous Waste Mixture, the waste is evaluated according to the Dangerous Waste Characteristics (WAC 173-303-090). The waste is evaluated in terms of its ignitability, corrosivity, and reactivity. If it is determined to manifest any of these properties and if it is produced in excess of the quantity specified, it is designated DW.

If the waste contains any constituents listed in (WAC 173-303-090) as EP Toxic, the concentration of these constituents is determined and compared to the concentration ranges specified, and the designation (DW or EHW) is determined.

If the waste does not meet the criteria of any of the previous categories, the Washington Department of Ecology may require that the waste be checked against the Dangerous Waste Criteria (WAC 173-303-100). If the constituents are known and there is toxicity and concentration data available, the Toxic Category and equivalent concentration are determined as in Step 4 above. Persistence and carcinogenicity are evaluated as described also. If sufficient information is not available, the waste stream is then evaluated using bioassay methods (WAC 173-303-110) to obtain toxicity data so that the Toxic Category and corresponding designation may be determined.

RANK ORDER CLASSIFICATION - STATE OF MICHIGAN DEPARTMENT OF NATURAL RESOUCES DEGREE OF HAZARD SCHEME

The proposed Michigan Waste Classification Scheme designates wastes as either managed or unmanaged under Michigan Act 64. The degree of hazard scheme is only one component of this process. The other considerations and their relationship to degree of hazard are depicted in Figure 9. The step-by-step classification procedure is described briefly in the following section.

Step 1: The list of exempted wastes in Rule 201 is consulted to determine if the waste is not subject to management under the act. The general categories of exempted wastes are presented in Table 43.

Step 2: If the waste is not exempt, Tables 301, 302a, and 302b, contained in the regulation, are consulted to determine if the waste is an EPA-Listed Hazardous Waste. The quantity generated is compared to Rules 301 and 302 to determine if the waste is regulated. The quantity exclusions addressed in the regulation are described in Table 44.

Step 3: If the waste is not listed, it is evaluated to determine if the waste contains the infectious or parasitic agents listed in Rule 305. If so, it is regulated.

Step 4: If the waste is not determined to be infectious, the toxicity of the waste is evaluated. Tables 303, 304, and 306 of the regulation are consulted to determine if the constituents are listed as Toxic, EP Toxic, or Severely Toxic, respectively. If the constituents are listed, their concentrations are determined and compared, together with the quantities produced, to specifications outlined in the corresponding Rules 303, 304, and/or 306 to determine regulatory status.

If the generator has knowledge that the waste has hazardous characteristics, even though it has not met any of the above criteria, the waste must be evaluated under Rule 204 by calculation of the toxicity score for each constituent as described in Chapter 3.

FIGURE

Michigan Department of Natural Resources
State Degree of Hazard Assessment Scheme

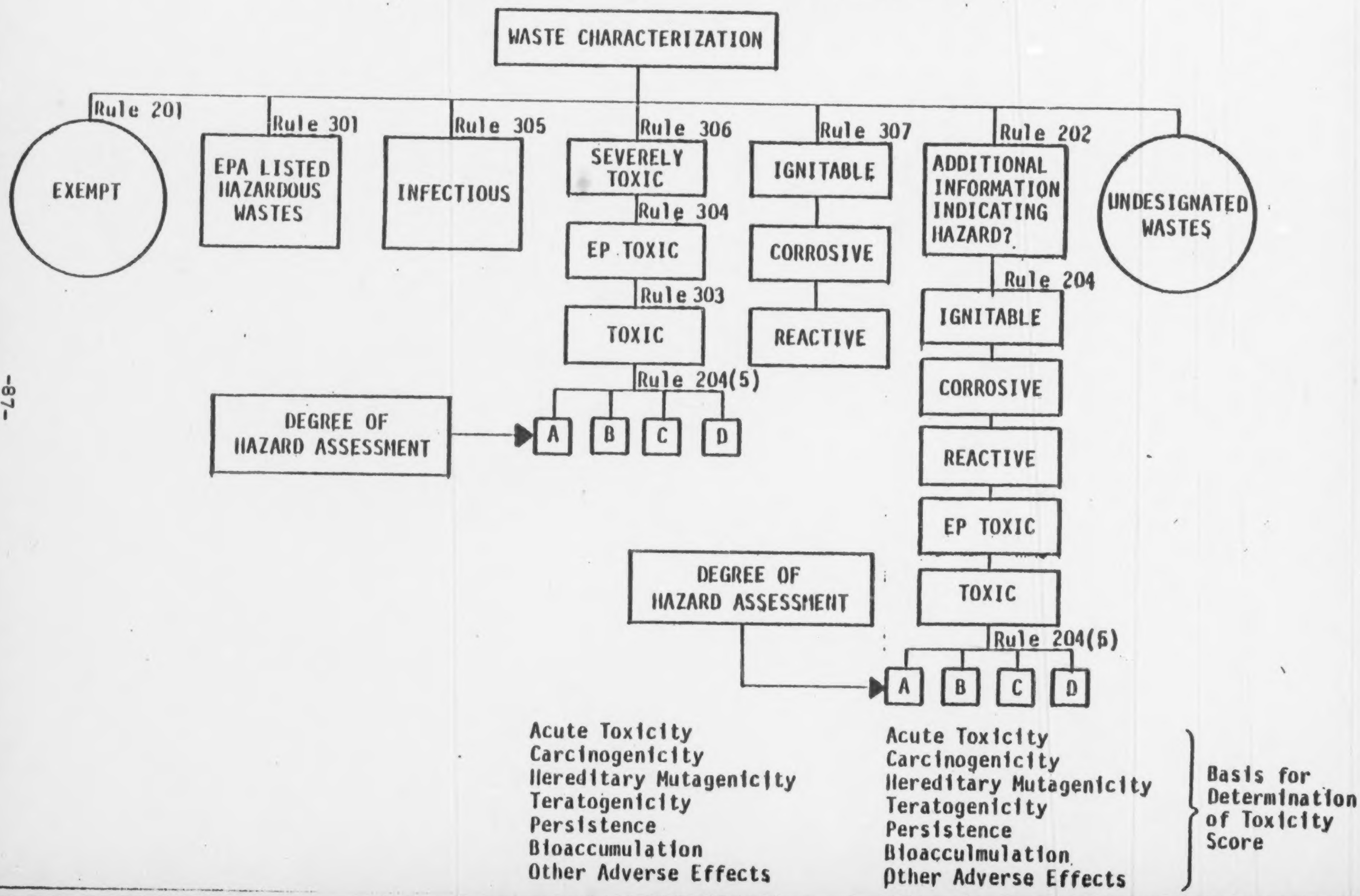

WASTE CHARACTERIZATION
Rule 201
EXEMPT
Rule 301
EPA LISTED HAZARDOUS WASTES
Rule 305
INFECTIOUS
Rule 306
SEVERELY TOXIC
Rule 304
EP TOXIC
Rule 303
TOXIC
Rule 204(5)
A
B
C
D
DEGREE OF HAZARD ASSESSMENT
Rule 307
IGNITABLE
CORROSIVE
REACTIVE
Rule 202
ADDITIONAL INFORMATION INDICATING HAZARD?
Rule 204
IGNITABLE
CORROSIVE
REACTIVE
EP TOXIC
TOXIC
Rule 204(5)
A
B
C
D
DEGREE OF HAZARD ASSESSMENT
UNDESIGNATED WASTES
Acute Toxicity
Carcinogenicity
Hereditary Mutagenicity
Teratogenicity
Persistence
Bioaccumulation
Other Adverse Effects
Acute Toxicity
Carcinogenicity
Hereditary Mutagenicity
Teratogenicity
Persistence
Bioacculmulation
Other Adverse Effects
Basis for Determination of Toxicity Score

TABLE 43

MICHIGAN DEPARTMENT OF NATURAL RESOURCES DEGREE OF HAZARD ASSESSMENT SCHEME GENERAL CATEGORIES OF EXEMPTED WASTES

1. Household wastes - garbage, trash, sanitary wastes
2. Material sold for treatment or recycling and stored for one year or less
3. Solid or dissolved material in domestic sewage discharge (except sludge)
4. Sludge from publicly-owned sewage treatment plant when disposed in permitted land treatment operation
5. Solid or dissolved material in irrigation return flow discharge
6. Authorized industrial discharge to municipal treatment system
7. Industrial point-source discharge subject to permit under Federal Clean Water Act (does not include sludges or other by-products of industrial wastewater treatment)
8. Industrial discharge which is a source, special nuclear, or by-product material as defined by the Atomic Energy Act of 1954. Exemption includes all forms of radioactive wastes which are not otherwise hazardous.
9. Materials subjected to in-situ mining techniques which are not removed from the ground as part of the extraction process.

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* Adapted from Michigan Rule 201

TABLE 44

MICHIGAN DEPARTMENT OF NATURAL RESOURCES DEGREE OF HAZARD ASSESSMENT SCHEME QUANTITY EXCLUSIONS

Michigan Rule No.	Category of Waste	Excluded Waste		
		Generated	Accumulated	Disposed
301	U.S. EPA-Listed Hazardous Waste	<100 kg/mo		<100 kg/mo
302	U.S.EPA listed			
	1. Commercial chemical product	≤ 1 kg/mo	≤ 1 kg/mo	
	Manufacturing intermediate	≤ 1 kg/mo	≤ 1 kg/mo	
	Off-specification commercial chemical product	≤ 1 kg/mo	≤ 1 kg/mo <	
	Manufacturing chemical intermediate	≤ 1 kg/mo	≤ 1 kg/mo	
	2. Container larger than 20 L and inner liners which held U.S. EPA-listed materials	≤ 10 kg*	≤ 10 kg	
	3. Residue or contaminated soil, water or other debris resulting from a spill of U.S. EPA-listed materials	≤ 100 kg		
303	Toxic Components of Wastes** Rating (Rule 204):			
	A	≤ 0.1 kg/mo		≤ 0.1 kg/shipment
	B	≤ 1 kg/mo		≤ 1 kg/shipment
	C	≤ 10 kg/mo		≤ 10 kg/shipment
	D	≤ 100 kg/mo		≤ 100 kg/shipment
304	EP Toxic Wastes	< 100 kg/mo		< 100 kg/shipment
306	Severely Toxic Wastes, containing ≥ 1 ppm of materials listed in Table 306	< 1 kg		

---

* Unless inner liner is triple rinsed using a solvent capable of removing the contaminant(s) or equivalently cleaned by another method; or the contaminated liner has been removed.

** For amounts generated in excess of these quantities, refer to Quantity of Waste/Component Concentration graph (Figures 2-5) for management status.

The steps in calculation of the toxicity score are:

a) The acute toxicity score is determined from available data specified in Rule 205(2)(a) for Oral LD_{50}, Dermal LD_{50}, Aquatic LC_{50}, and Inhalation LC_{50}.

b) Available carcinogenicity data is summarized and a score assigned from Rule 205(2)(b).

c) Available data concerning hereditary mutagenicity is summarized and a score assigned from Rule 205 (2)(c).

d) Available teratogenicity data is summarized and a score assigned for Rule 205 (2)(d).

e) The half-life of the constituent in soil or water is determined and a score assigned for persistence from Rule 205 (2)(e).

f) A score is assigned for "other adverse effects" as defined in Rule 205(2)(g).

The information required for these scores may be obtained from the literature, but the Michigan DOE is to be consulted for procedures to determine data where data are lacking. From the scores, the Toxicity Rating (A,B,C or D) is determined from Rule 204 (Table 11 in Chapter 3). For each constituent the component concentration is determined. For each component, the concentration and total waste quantity produced are applied according to Rule 204 to the graphs shown in Figures 3, 4, 5, and 6 in Chapter 3, and the regulatory status ("managed" or "not managed") of the waste is determined. The waste is ultimately managed based on the most restricted of its constituents.

Step 5: If the waste is not regulated as a Toxic Waste, Table 307 of the regulation is consulted to determine if the waste or its components exhibit the characteristics of reactivity, corrosivity, or ignitability. If so, the quantity of waste produced is compared to Rule 307 of the regulation and if the quantity specified is exceeded, the waste is regulated.

Appeal Procedure

If, according to this classification scheme, the waste is determined to be hazardous but the generator has information to indicate otherwise, he may appeal the hazardous waste designation by the procedure summarized in Table 45.

MICHIGAN AND WASHINGTON SCHEMES: MAJOR DIFFERENCES

The application of the two state schemes to the case study waste steams revealed three interesting differences in the approaches. These differences can be characterized as related to treatment of carcinogenicity potential; approach to waste disposal requirements; and comprehensiveness of scheme evaluations.

TABLE 45

MICHIGAN DEPARTMENT OF NATURAL RESOURCES DEGREE OF HAZARD ASSESSMENT SCHEME APPEAL PROCEDURE

Criteria for Redesignation

- Demonstrate that the waste does not possess hazard characteristics which led to its listing by the USEPA.
- Demonstrate that due to lack of mobility or persistence, a waste listed for ignitability, corrosivity, reactivity, toxicity, EP presents no immediate or future hazard to human health or the environment.
- Demonstrate that the waste fails to meet criteria of a toxic or severely toxic waste by replicating the types of toxicity tests which led to the listing of the waste as hazardous. (Test protocols may be obtained from the Department of Natural Resources).

Invalidation of Redesignation

- Any change of components, physical state, conditions of the generating process, or other variation which would increase mobility, persistence, or hazardous characteristics of the waste invalidates the redesignation and requires reevaluation of the waste.

Management Requirements During Appeal Procedure

- Wastes for which appeals are under consideration must be managed as hazardous until redesignation is granted.

Treatment of Carcinogenicity Potential

While carcinogenicity data are considered in waste designation by both schemes, the Washington scheme applies an interesting concept to the evaluation of these data. This scheme defines persistent constituents as belonging to two specific chemical families (PAH and HH), and also assumes that carcinogenic substances belong to these families. Thus, a waste containing carcinogenic PAH's or HH's is regulated as EHW because of its persistence, not because of its carcinogenicity. This characterization is different from the Michigan scheme which bases classification of both persistent and carcinogenic chemicals on the analytical and toxicological data for each. While the Washington scheme addresses carcinogenicity, there is no mechanism whereby wastes defined as carcinogenic can be designated EHW solely on that basis.

Management Approach

The Michigan scheme does not specify waste management requirements based on waste characterization as the Washington scheme does. Washington, by contrast, issues permits to to disposal facilities for specific wastes. Thus a management facility rather than a management technique is specified and approved. Acceptable management techniques are thus defined through the issuance of permits to facilities to handle specific wastes. Neither scheme combines hazard classification with generalized management requirements.

Scheme Comprehensiveness

Because of the sequential consideration of waste properties in the Michigan scheme it is possible for a hazardous waste to slip undefined through the classification process. The proposed regulation does not, as the Washington scheme does, expressly direct a generator to examine a waste with respect to all the categories in the scheme. For example, unless a manifest is required for disposal (which would require a generator to describe the characteristics and constituents of his waste in detail), a waste which was infectious but also toxic might be placed under the infectious waste category and never be evaluated with respect to its toxicity. Thus, a generator might opt to disinfect a waste on-site and place the residual material in a sanitary landfill which would not provide sufficient environmental protection considering the waste's toxicity.

CHAPTER 6

THE DEVELOPMENT OF A NATIONAL HAZARDOUS WASTE MANAGEMENT PROGRAM INCORPORATING DEGREE OF HAZARD

The Classification by Degree of Hazard Project provided an opportunity to test a concept which was previously only a topic of conjecture. The study results demonstrate that the various schemes do distinguish wastes of varying hazard potential in accordance with the assumptions upon which the schemes are based. Of course the development of a national degree of hazard scheme will require the establishment of defensible and logical assumptions. The strength of the scheme and its acceptability to the regulated and regulating communities, as well as to the public, will be determined by the validity of those assumptions.

The anticipated difficulties inherent in the task of applying the toxicological data base to the schemes were confirmed by the case studies. Problems of data availability, interpretability, and variability characterized the scheme application exercise. While the limitations of the data base for practical applications are acknowledged, the prospect of using it to promote regulation by prequalification rather than exemption through disqualification has emerged as a possible regulatory option.

The hazard assessment schemes applied and studied in the course of this project incorporate a fundamental provision lacking in the existing Federal regulatory program. While the state schemes provide for facility-by-facility exemptions before regulation based on predetermined formulae for the assessment of hazard potential; the Federal program imposes blanket regulatory coverage for all facilities generating certain wastes, allowing only after-the-fact exclusions for those facilities that successfully complete the delisting process. The delisting process is time-consuming and expensive, and basically considers degree of hazard factors in the granting of variances.

The state scheme exemptions are based on three major factors: waste constituent toxicity, constituent concentration, and waste quantity. There is evidence to suggest that EPA also considers these characteristics relevant to hazardous waste management. Existing Federal regulatons reference these considerations in the criteria for identifying the characteristics of hazardous wastes (Federal Rgister, May 19, 1980; Environmental Protection Agency, Hazardous Waste and Consolidated Permit Regulations, Subpart B, § 261.10) and even address them in the regulatory regime for some special cases. For example, the EPA regulations address waste quantity and toxicity in determining the small generator exemption. Similarly, constituent concentration prominent in the degree of hazard schemes is referenced, albeit indirectly, in the Federal regulations covering "characterized" wastes.

Although the degree of hazard elements are present to some extent in the EPA regulations, the regulations lack a commitment to these concepts, as evidenced by the absence of limits and standards for their application to regulatory determinations for the range of wastes generated nationally. The establishment of an acceptable regulatory program based on degree of hazard requires the joint commitment of the regulated and regulating communities to the design of scientifically defensible and technologically feasible standards and criteria. These criteria must be based on accurate waste characterization data and reliable toxicological information. The rationale for the design of each degree of hazard criterion and its associated boundary values must be stated explicitly within the context of the waste classification procedure so that the regulated and regulating communities understand the purpose of each dimension of hazard analysis. This task will require that judgments be made concerning such issues as the validity of addressing absolute vs. relative toxicity. It will require deciding to regulate either according to an equivalent concentration approach or a single constituent concentration approach; or possibly to require the development of bioassay data for actual waste samples.

At the outset of the development of such a program the following challenges would have to be met by the regulating community:

- The establishment of defensible estimates of relative toxicity for hazardous constituents;
- The specification and maintenance of a data base suitable for degree of hazard computation;
- The establishment of mechanisms for assessing levels of hazard for wastes containing more than one toxic constituent; and
- The establishment of assessment methods to address public health risks based on site-specific as well as waste-specific features.

DEGREE OF HAZARD-BENEFITS TO INDUSTRY

The primary benefits to industry of adopting this regulatory approach would be a reduction in regulatory uncertainty. The regulatory parameters would be stated explicitly and the corresponding management parameters could be effectively factored into fiscal and operational planning initiatives. This reduction in planning uncertainty would translate into cost savings for industrial managers.

Ideally the degree of hazard program would also translate into more direct waste management cost savings by matching the costs of waste disposal to the degree of hazard of the wastes. Providing for this kind of cost:hazard relationship is an unrealistic goal at the present time. Management options are limited by waste characteristics that do not correspond to degree of hazard characteristics. The levels of environmental control are also not graduated to match hazard potential for the universe of non-nuclear industrial hazardous waste.

For example, in terms of landfill waste management options currently available, the only existing alternatives are sanitary and secure landfill design. Both designs require liners, leachate recovery systems and clay covers. The principal difference between the two options is that the 30-year post-closure management requirement does not apply for new sanitary landfills, but is an intrinsic cost item of secure landfill design and operations. The data presented in Table 46 exemplify the relative cost margins for secure and sanitary landfilling. Incineration costs are estimated for comparative purposes. The unit costs exemplify several trends:

- The cost differential between sanitary and secure landfills does not exceed 25 percent at any given capacity;
- Because the typical sanitary landfill exceeds 1,000 tons/day in capacity, and the typical on-site secure landfill is less than 100 tons/day, the perception exists that there are significant cost differentials between the two modes of disposal; and
- Incineration costs are from four to six-fold greater than secure landfilling, at any given capacity

For example, waste disposed in a secure landfill at a rate of 100 tons/day costs $90/ton. If it were assumed that the waste could be rendered non-hazardous if the hazardous constituents were reduced in concentration by 10 percent, and that the bulking of the waste to achieve this would cost $3/ton, then the cost of disposing the bulked waste in a sanitary landfill would be $70 + $3, or $73/ton, at the 100 ton/day capacity.[1] However, the bulking itself would result in a 10 percent increase in the tonnage to be disposed, meaning that the disposal cost per ton of originally hazardous waste would be equal to (1.1)(73) or $80.30/ton by sanitary landfilling, vs. $90/ton by secure landfilling.

The preceding example suggests that a degree of hazard concept would rationalize the *de minimis* concentration situation allowing consideration of tradeoffs between bulking of wastes and level of disposal. There are obviously other tradeoffs inherent in the degree of hazard concept, but these generally involve concentration reduction to the point where reclassification is plausible.

The real cost advantage associated with a degree of hazard classification system can be realized only if the total system cost for waste management from source through selected processing/recycling alternatives to disposal is less with the classification system than without. The total system cost is what an industry pays to support all the required management activities from waste segregation at the source and separate transport and/or processing, to disposal. The unstated rule of waste conversion/separation technology is that the more concentrated the material, the less its unit cost will be for separation or conversion. To this end, it is vital for industries to segregate wastes at the source, to preserve opportunities for cost savings under a degree of hazard classification scheme.

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[1] Such measure would be unlikely to reduce the hazard loading for the classification schemes examined in this report.

TABLE 46

SUMMARY OF INCINERATION AND LANDFILLING COSTS

Technology	Unit Cost ($/ton) at Indicated Capacity (tons/day) 10	26	100	200	800
Incineration(1)	-	400	260	-	200
Sanitary Landfill	220	-	70	65	30
Secure Landfill(2)	250	-	90	85	40

Note:

[1] Includes cost of residuals disposal.
[2] Includes prorated closure and post-closure costs.

Source: Estimates prepared by Engineering-Science updated to December 1981.

COMPONENTS OF A NATIONAL REGULATION INCORPORATING DEGREE OF HAZARD

Although the toxicity/quantity/concentration approaches to hazard assessment suggest a possible avenue for improving the standardization and efficiency of hazardous waste regulation, they neglect site-specific features. The development of a defensible national policy requires that site-specific issues be factored into the degree of hazard assessment. For example, if a waste stream containing a soluble, persistent, toxic constituent were generated by two different facilities at the same concentrations and in the same quantities, the quantity/concentration graphs of either of the state schemes would rank these wastes as equivalent in their relative hazard potential. However, if one were disposed in a secure landfill, located in a low density environment, remote from any drinking water supplies; and the other disposed in a sanitary landfill overlying a drinking water source, in a densely populated area, the potential hazards of the respective situations would not, in truth, be equal. The toxicity/quantity/concentration approach to hazard assessment can be improved measurably by considering disposal site suitability based on population risk and consideration of environmental factors.

Even a casual overview of hazard assessment schemes applied to a minute subset of the universe of hazardous wastes reveals the complexities inherent in the design of an equitable, understandable, and enforceable national regulatory program. The array of parameters considered in hazard evaluations reflects the overwhelming diversity not only of the chemical wastes themselves, but of the myriad other variables which confer hazardousness on a given disposal, or management situation. The development of a regulatory decision tree or formula to lead waste managers from hazard assessment to safe and economical management responses is a complex challenge. This prospect echoes the complexity of deciphering the diverse contingencies characteristic of food web analyses of ecological systems as contrasted with the more simplistic, linear, less realistic food chain approach. Many more variables bear on the equation linking hazard potential to management remedy than a linear conceptualization permits. A responsible program must at least address waste constituent properties; waste quantities; constituent toxicity/carcinogenicity and persistence; toxic constituent concentrations; site suitability for various treatment and disposal options; population at risk; and economic and technical feasibility of treatment and disposal technologies.

Of this array of variables, toxicity, carcinogenicity and persistence probably represent the most uncertain as well as the most fundamental considerations. The value of a degree of hazard scheme to society lies in the degree of improved public health and environmental protection it provides. This protection is predicated on our capacity to recognize the agents of hazard which these variables help to define.

Hundreds of new synthetic compounds are introduced into the environment each year. Maintaining a reliable data base to assess their relative toxicity, carcinogenicity, and persistence is not possible. Even those compounds which are relatively well-studied are ordinarily evaluated on the basis of animal and bacterial studies. The relationship between a particular chemical's effect on a rabbit, rat or fish and its effect on a human being is not quantifiable. Yet, animal studies are our best gauge of relative toxicity.

The limitations of the extant data base raise some basic concerns relative to degree of hazard scheme design and application. Because many potentially hazardous chemicals are not well-studied, a defensible degree of hazard scheme must provide for uncertainty so that comparatively unstudied chemicals do not rank low in hazard assessment as a result of factoring data gaps into the summary analysis. Perhaps the ultimately acceptable degree of hazard regulation should require that a certain battery of tests be conducted on any uncharacterized chemical before its official toxicity rating is determined. This approach would provide incentives for government and industry involvement in the development of a more complete toxicity data base which could ultimately facilitate the conduct of better substantiated hazard evaluations.

In any case, if a degree of hazard system is implemented, the corresponding regulation should specify a particular data base to be consulted in the application of the assessment scheme. This data base should be formatted so as to facilitate interpretation of data for the purposes of the national degree of hazard approach. It should also be easily accessible and represent state of the art information. Similarly the physical/chemical data required by the national system should be organized and made available for universal access.

PROPOSED REGULATORY FRAMEWORK

Although the reasonableness of providing management formulae specific to situations of graduated hazard potential may be questionable, regulatory precedents, which can offer improved public health and environmental protection as well as regulatory relief, do exist. As an example, the dredge and fill permit program of the U. S. Army Corps of Engineers offers a hierarchical approach to the regulation of construction and related activities in navigable waters[1]. Under the Corps program, three types of permits are issued for dredge and fill activity in navigable waters. These regulatory levels represent a hierarchical approach to regulation which is based on relative potential for environmental disruption.

Under this system, at the end of the spectrum of activities representing the lowest hazard potential, the regulations provide criteria defining projects which are permitted on a nationwide basis without individual permit review. If a given proposal meets the specific guidelines defining this category, the applicant conducts the work under a "nationwide permit" and the specifics of the project are not reviewed by the Corps. Rather the applicant receives a letter of permission after notifying the Corps of the planned activities.

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[1] Regulatory Program of the Corps of Engineers, Federal Register, 19 July 1977, Part II.

In the middle of the spectrum of environmental disruption potential, the Corps issues General Permits on a district-bydistrict basis. General permits outline activities which can be under-taken in a particular region without extensive permit review, provided they meet specific design and environmental criteria. The project criteria for these categories of activities are drawn up by the Corps so as to provide environmental protection and reduce regulatory burden on individuals undertaking these comparatively low impact projects.

At the highest hazard end of the spectrum are projects requiring individual review and comment because they suggest greater potential for environmental disruption. These proposals are reviewed by the Corps and by the federal environmental agencies. In many cases design recommendations are offered, based on site visit observations, to provide environmental protection where feasible. Often environmental recommendations are made stipulations of the final permit. Thus, theoretically, the time and resources of the regulatory agency are expended in consideration of the proposals characterized as having the greatest hazard potential.

A similar hierarchial approach to hazardous waste management site permitting might first involve the establishment of criteria which relate to waste mobility, toxicity, population at risk, and magnitude of hazard potential as defined by waste quantity and concentration of toxic constituents. For example, the following specific categories might be included as landfill criteria for the lowest level of hazard category:

- Waste handling/storage criteria: Ignitability, reactivity, corrosivity;
- Waste disposal criteria: constituent toxicity range, carcinogenicity/persistence ratio; solubility; concentration of constituents; and quantity of waste; and
- Site criteria: Local population; distance from facility to nearest drinking water source; land use characteristics; distance to nearest surface water; depth to groundwater; soil permeability; bedrock permeability; depth to bedrock; use of liners; use of leachate collection system; and other environmental controls.

Allowable ranges for the above variables as well as interdependent variables (e.g., quantity/concentration) would be specified. If a generator/disposer could demonstrate that the facility operated within those ranges, the permitting agency would not conduct an elaborate permit review. Rather the agency might provide specific design and performance standards for these facilities.

A second set of ranges for the criteria could be established to define a second level of hazard potential. Facilities conforming to these levels might receive a permit contingent on additional groundwater and/or surface water monitoring and reporting requirements and stricter design standards.

Waste disposal situations exceeding the second level criteria would be those for which the regulatory agency would focus site and management practice scrutiny. In-depth facility studies would be conducted and management, design or monitoring requirements would be specified which would reduce the inherent risks to an acceptable level.

This kind of hierarchical approach suggests the following advantages:

- It reduces regulatory burden on low hazard facility operations;
- It provides predictable and definitive criteria to guide industrial managers;
- It allows the use of low to moderately trained personnel to perform initial screening activities;
- It concentrates the efforts of highly trained professionals on the most hazardous situations and on a limited number of facilities defined as high hazard;
- It is objective and reduces the possibility of capricious permitting decisions;
- It would be based on a sound technical arguments relating to hazard potential;
- A specific set of critera could be established for each waste management option (e.g., incineration, landfilling) so that degrees of hazard would be management option-specific; and
- A specific set of criteria could be established for pre- and post-treatment for wastes that pose handling rather than disposal hazards. Once a non toxic, but perhaps corrosive waste were treated so as not to be corrosive, it could be classified as low risk.

The above discussion merely provides a framework for consideration as we continue our efforts to revise the hazardous waste management regulations to more effectively and efficiently realize the intent of Congress relative to RCRA. The knowledge exists to design and apply a degree of hazard concept. The data-related caveats are evident and must be addressed responsibly. The real obstacle to implementing degree of hazard may lie in the ability of industry and government to cooperate in the development and approval of a responsible regulatory approach.

APPENDIX A

GENERAL WASTE STREAM CHARACTERIZATIONS AND CONSTITUENT PROPERTIES

Brine Purification Muds from the Mercury Cell Process in Chlorine Production Where Separately Prepurified Brine Was Not Used

EPA Hazardous Waste Identification Number: K071

This waste contains the toxic constituent mercury and is listed by EPA as a hazardous waste because of its toxicity. Approximately 42,000 tons (dry basis) of brine purification muds are generated annually. While about 27 production sites were formerly operating, sources indicate an industry trend toward gradual phasing out of this process in favor of the diaphragm method of chlorine production.

Chlorine production facilities ordinarily generate muds or sludges, which are contaminated with mercury in various complexes, and magnesium hydroxide, and barium sulfate. These inorganic constituents resist biodegradation and have poor combustion potential.

Treatment of these sludges most often involves neutralization, filtration, sedimentation, precipitation or recycling to reduce the mercury levels in the disposed waste. Successful landspreading is practiced, although restrictive measures place limits on application rates, require pH control; and must be tailored to accommodate various site characteristics. Recycling of mercury is reportedly not an economical waste management option although one plant currently sells wastes to a reclamation firm. Low concentrations of mercury (in parts per million) in wastes render recycling infeasible. Firms must generate sludges containing over 20 percent mercury before a net recycling benefit is realized by a given production facility. These wastes ordinarily do not contain such high concentrations of mercury.

Case study information indicates that secure landfilling is the preferred disposal option for this waste. The possibility exists for delisting brine purification muds on a plant-by-plant basis depending on mercury concentration and waste handling methods.

Table A-1provides a summary of various physical, chemical, and toxicological characteristics of mercury.

WASTE: K071 - Brine purification muds from the mercury cell process in chlorine production where separately prepurifie brine was not used
CONSTITUENT: Mercury

TOXICITY

ORAL	AQUATIC	DERMAL	CHRONIC	CARCINO-GENICITY	MUTAGEN-ICITY	TERATO-GENICITY	BIOACCUMU-LATIVITY	SAX RATING	ANTAGONIS EFFECTS
Rat LD_{50} 37 mg/kg Rat LD_{50} 76 mg/kg Rat LD_{50} 210 mg/kg Rat LD_{50} 297 mg/kg Rat LD_{50} 57 mg/kg (12)	$HgCl_2$: LC_{50} rainbow trout 155-903 μg/1 Methyl-mercuric compounds: rainbow and brook trout LC_{50} 24-84 μg/1 Phenyl-mercuric acetate LC_{50} 5.1 μg/1 Merthioalate: LC_{50} 39,910 μg/1 TLm96 (marine) mummichog: 800 & 2000 μg/1 $HgCl_2$ (2)		Methyl Hg: CNS damage, paresthesia of extremities, slurred speech, unsteadiness, cerebellar atrophy Ethyl Hg: renal and cardiac damage Hg vapor: mental disturbances, tremors, gingivitis, lung damage, kidney dysfunction (2) Various chronic effects observed at low concentrations 0.12-0.93 μg/1 (12)	No data (2)	Methyl-mercury: bacteria, human positive (2) Elemental or inorganic mercury: no data (2)	Methyl-mercury: animal positive; $HgCl_2$ animal positive; Alkyl Hg compound: animal positive (2)	Methyl-mercury chloride juvenile rainbow trout: 4532-8049 brook trout: 12,000-20,000 fathead minnow: 62,898 [this number most accurately portrays field conditions] Half-lives of Hg compounds-clearance not rapid even after several months (2)	HIGH to CNS, GI tract (10)	

PHYSICAL

NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBIL-ITY	VAPOR PRESSURE	AESTHETICS	FLAS POIN
	Elemental mercury can be oxidized to the mercuric form (+2) in water in the presence of oxygen; facilitated by presence of organic substances (2) Dimethyl & monomethyl mercury may be formed by bacteria present in sediments (2) Demethylation can also be done by bacteria, thus limiting the buildup of methylmercury in the environment (2)		Insoluble (12)	.0012 mm Hg @ 20°C (2) 1 mm Hg @ 126.2°C (8) (10)		

Bottom Stream from the Acetonitrile Column in the Production of Acrylonitrile

EPA Hazardous Waste Identification Number: K013

The acetonitrile column bottom streams contain considerable amounts of acetonitrile, acrylonitrile, and hydrocyanic acid and are designated by EPA as toxic. Approximately 337,000 tons of this waste are reportedly generated annually by six production facilities. It ranks as a high volume waste stream that is characterized by a high toxicity rating, high mobility, solubility and volatility, and thus represents a waste with limited management options.

Treatment of this waste commonly involves ponding and secure landfilling. This technique, however, has limitations due to the tendency of the constituents to dissolve clay liners. The wastes may be neutralized and, once concentrated, can be incinerated. Alkaline hydrolysis produces a biodegradable effluent that may be discharged to publicly-owned treatment works.

Tables A-2 through A-4 provide a summary of various physical, chemical, and toxicological characteristics of the waste constituents.

TABLE A-2

WASTE: K013 - Bottom stream from the acetonitrile column in the production of acrylonitrile.

CONSTITUENT: Acetonitrile

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONI EFFECT
Rat LD$_{50}$ 3800 mg/kg (1) (3) (10)	TLm 96: 1000 ppm (1) 1020 ppm (hard water) 1000 ml/1 (soft water) 1850 ppm bluegills 1650 ppm guppies (soft water) (2)	Rabbit LD$_{50}$ 1250 mg/kg (10) (1) Rabbit LD$_{50}$ 980 mg/kg (2)	Animals: bronchial inflammation, renal lesions, bronchitis, reduction in body weight (2) no discussion of reversibility	Animal negative (2)	No data (2)	Animal positive (2)		MOD via oral, inhal, ip, dermal routes (10)	

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
Health: 2 Flamm: 3 React:* 1 0 (9) [*two different values were quoted in one source]	Basic soils may provide release of CN; high organic or surface area clays will have best capacity. (3) - Overall degradation rate = 2.3x10^{-2}/hr; slowly degrades to CN$^-$ which is persistent (3) Products of decomposition are highly toxic (3)	K$_{ow}$: 10^{-34} (3)	Miscible (3) reacts with water to form flammable and toxic vapors (3) Soluble in all proportions (5) (8) Water Soluble (9)	100 mm Hg @ 27°C (10) 73 mm Hg @ 20°C (2) 1.3 psia @ 74 torr (3) 40 mm Hg @ 7.7°C 60 mm Hg @ 15.9°C 100 mm Hg @ 27.0°C 200 mm Hg @ 43.7°C (8)	Odor threshold: 40 ppm (3)	42°F (open cu (10) 42°F 6°C (open cu (9)

TABLE A-3

WASTE: K013 - Bottom stream from the acetonitrile column in the production of acrylonitrile.

CONSTITUENT: Acrylonitrile

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINO-GENICITY	MUTAGEN-ICITY	TERATO-GENICITY	BIOACCUMU-LATIVITY	SAX RATING	ANTAGONISTIC EFFECTS
Rat LD_{50} 82 mg/kg (1) (7) (10) Rat LD_{50} 93 mg/kg (3) Rat LD_{50} 81 mg/kg (12)	TLm 96: 100-10 ppm (1) TLm 96: 10.1-18.1 ppm fathead minnow 24.5 ppm saltwater pinfish (2) TLm96: bluegill 11.8 mg/1 TLm96: bluegill 720 ppm (12)	Rabbit LD_{50} 250 mg/kg (1) Rabbit LD_{50} 280 mg/kg (10)	Little evidence of cumulative action on repeated exposure (10) animals: lesions in CNS, func. disorders of resp. & cardiovascular system humans: liver injury, CNS disorders, headache, fatigue, nausea, anemia, blood problems, jaundice, etc. (2)	Human suspected (1) animal positive (2)	Bacteria positive (1) (2)	Animal positive (2)	Bluegill in 28-day study bioconc. 48-fold w/1/2 life of 4-7 days (2) (3) weighted average factor of 110 for edible fish/shell fish consumed by Americans (2) (3)	HIGH via oral & dermal (10)	HCN and CO were found to enhance acrylonitrile toxicity in experimental animals as we as in workers engaged in acrylonitrile production (2) effects simil to HCN (10)

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBIL-ITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
Health: 4 Flamm: 3 React: 2 (9)	Short lived in the aqueous environment: 10 ppm solution completely degraded after 6 days in Mississippi River water (2) (3) undergoes photodegradation to saturated derivatives (3)	Log: 0.14 Log K_{ow}: -0.92 (3)	7.35 gm/100 gm H_2O @ 20°C (3) soluble (8) water soluble (9) soluble in all common organic solvents (12)	80 mm Hg @ 20°C (2) (3) [explosive, flammable] (2) 100 mm Hg @ 22.8°C (10)	Odor threshold: 2.14 ppm (3)	30°F (closed cup) (10) 32°F 0°C (open cup (9)

TABLE A-4

WASTE: K013 - Bottom stream from the acetonitrile column in the production of acrylonitrile.

CONSTITUENT: Hydrocyanic Acid

TOXICITY

ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONIS EFFECTS
Rat LDL_o 10 mg/kg (1) Mouse LD_{50} 3.7 mg/kg (1) Mouse LD_{50} 4 mg/kg (3) Mouse LD_{50} 3.7 mg/kg (10)	TLm 96: <1 ppm (1)						Has no accumulative effects (3)	VERY HIGH via oral, dermal, inhal, iv,ip,im (10)	

PHYSICAL

NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
Health: 4 Flamm: 4 React: 2 (9)	Natural alkalinity will slowly reduce acidity; HCN gas will dissipate over a period of time. (3)	Log K_{ow}: -0.25 (3)	$1x10^6$ ppm @ 25°C (3) Solubilizes & ionizes w/heat evolution in water; not a strong acid; remains undissociated at low pH (3) Soluble in all proportions (5) (8) Water soluble (9)	546 mm Hg @ -18°C 360 ton @ 7°C 658.7 ton @ 21.9°C 100 mm Hg @ 17.8°C (3) 400 mm Hg @ 10.2°C 760 mm Hg @ 25.9°C 2 atm @ 45.8°C (8) 400 mm Hg @ 9.8°C (10)	Odor threshold: 1.0 ppm Taste threshold: .001 ppm (3)	0°F (closed cu (10) 0°F -18°C (9)

Chlorinated Hydrocarbon Wastes from the Purification Step of the Diaphragm Cell Process Using Graphite Anodes in Chlorine Production

EPA Hazardous Waste Identification Number: K073

This waste, resulting from the diaphragm cell process of chlorine production, is listed because it contains several toxic organic constituents in high concentrations. These constituents include chloroform, carbon tetrachloride, hexachloroethane, trichloroethane, tetrachloroethylene, dichloroethylene and 1,1,2,2- tetrachloroethane. All of these substances exhibit substantial carcinogenic potential.

Management practices include solar evaporation, neutralization, deep well injection, and encapsulation prior to landfilling. Due to possible problems related to the release of fugitive emissions during solar evaporation; encapsulation/landfilling, incineration, and deep well injection are the preferred disposal options. However, strict waste management controls must be employed, especially for incineration, as improper combustion can generate toxic levels of phosgene gas.

Tables A-5 through 13 provide a summary of various physical, chemical and toxicological characteristics of the waste constituents.

TABLE A-5

WASTE: K073 - Chlorinated hydrocarbon wastes from the purification step of the diaphragm cell process using graphite anodes in chlorine

CONSTITUENT: Chloroform

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINO-GENICITY	MUTAGEN-ICITY	TERATO-GENICITY	BIOACCUMU-LATIVITY	SAX RATING	ANTAGONIS EFFECTS
Rat LD_{50} 800 mg/kg (1) (7) (10) Rat LD_{50} 1875 mg/kg (3) Rat LD_{50} 450 mg/kg Rat LD_{50} 300 mg/Kg (12)	TLm96: 100-10 ppm (1) TLm96: 43.8 & 66.8 ppm (rainbow trout) 100-115 ppm (bluegill) (2) Bluegill 96 hr LC_{50} 18 mg/1 (12)		Animals, humans: liver and kidney problems, neurological disorders (2) Narcosis, liver and heart damage (10)	Animal positive (1) (2) Human suspected (2) Animal suspected (1)	Bacteria negative (2)	Animal positive (2) Animal positive (1)	In 14-day study, bluegill bioconc. 6 times - tissue half-life: <1 day; estimated bioconc. factor for edible port. fish/shellfish by Americans: 14 (2)	MOD via oral, inhal (10)	Toxicity o chloroform enhanced b ethanol & high-fat low-protei diet (2)

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBIL-ITY	VAPOR PRESSURE	AESTHETICS	FLA POI
Health 2 Flamm: 0 React: 0 (9)	Relatively stable; when exposed to sunlight, decomposes slowly in air but is rel. stable in water; half-life for hydrolysis is 15 months in light, 18 months in darkness. (3) Degradation can occur in water in presence of metals & is accelerated by aeration. (2) Very persistent: persistence in unadapted soil = >2 years (Cat 5). (4) Volatility, then photodegradation are important degradation mechanisms. (3) Adsorption proportional to organic content of soils & surface area of clays (3)	Log K_{ow}: 2 Log: 2 (3)	7420 mg/1 @ 25°C (2) 8200 mg/1 @ 25°C (3) Slightly soluble (5) .82 pph @ 20°C (8)	200 mm Hg @ 25°C (2) 160 mm Hg @ 20°C (3) 60 mm Hg @ 0.5°C 100 mm Hg @ 10.4°C 200 mm Hg @ 25.9°C 400 mm Hg @42.7°C (8) 100 mm Hg @ 10.4°C (10)	Odor threshold: 205-307 ppm (3)	None (

TABLE A-6

WASTE: K073 - Chlorinated hydrocarbon wastes from the purification step of the diaphragm cell process using graphite anodes in chlorine
CONSTITUENT: Hexachloroethane

TOXICITY

ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONIS EFFECTS
Rat LD_{50} 6000 mg/kg (1) Rat LD_{50} 4460 mg/kg Rat LD_{50} 7080 mg/kg Rat LD_{50} 5160 mg/kg Rat LD_{50} 7690 mg/kg (12)	LC_{50}: (bluegill sunfish) 980 µg/1 (sheepshead minnow) 2.4 mg/1 (2)		Human: liver, kidney & heart degeneration, CNS depression. Animal hepatotoxicity, nephrotoxicity. (2)	Animal positive (1) (2) Mouse positive Rat negative (1)	Bacteria negative (2)	Animal negative (2)	Wt. ave. bioconc. factor for edible portions of fish & shellfish consumed by Americans: 320 (2) BCF in freshwater bluegill sunfish: 139 (2)	HIGH via iv MOD via sc probably MOD-HIGH via oral & dermal (10)	

PHYSICAL

NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
	Very persistent: persistence in unadapted soil = >2 years (Cat 5) (4)	K_{ow} 18 (3)	50 ppm insoluble in water (3) .005 pph @ 22°C (8) Insoluble (5)	1 mm Hg @ 32.7°C (3) Volat. half-life: 45 min (3) 1 mm Hg @ 32.7°C 5 mm Hg @ 49.8°C (8) 1 mm Hg @ 32.7°C (10)	Odor threshold: 0.01 mg/1 in water (3)	Not combustib (11)

TABLE A-7

WASTE: K073 - Chlorinated hydrocarbon wastes from the purification step of the diaphragm cell process using graphite anodes in chlorine
CONSTITUENT: Trichloroethane 1,1,2-

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINO-GENICITY	MUTAGEN-ICITY	TERATO-GENICITY	BIOACCUMU-LATIVITY	SAX RATING	ANTAGONI EFFECTS
Rat LD_{50} 1140 mg/kg (1) (7) (10) Rat LD_{50} 100 mg/kg (3)	TLm96: 100 - 10 ppm (1) TLm96: bluegill 40.2 mg/1 (2)		Animal: liver & kidney toxicity (10)	Animal positive (1) (2)	No data ; (2)	No data (2)	Wt. ave. bioconc. factor: 6.3 BCF: 13 (3)	HIGH via iv, sc MOD via ip, inhal, oral & probably dermal (10)	

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBIL-ITY	VAPOR PRESSURE	AESTHETICS	FL PO
Health: 3 Flamm: 1 React: 0 (9)	Very persistent: persistence in unadapted soil: >2 years (Cat 5). (4) Adsorption in soil proportional to organic content & surface area of clays; decomposes in water or steam; hydrolysis half-life in light or dark: 6 months; volatility more important than photo-degradation. (3)	K_{ow}: 158.5 (3)	Slightly soluble in water - 200 mg/1 (3) Slightly soluble (5)	40 mm Hg @ 35.2°C (10) 19 mm Hg @ 20°C 40 mm Hg @ 35.2°c (3) Half-life due to evap in water = 22 min (3) 10 mm Hg @ 8.3°C 20 mm Hg @ 21.6°C 40 mm Hg @ 35.2°C 60 mm Hg @ 44.0°C (8)	Odor threshold: 400 ppm (3)	None (12)

TABLE A-8

WASTE: K073 - Chlorinated hydrocarbon wastes from the purification step of the diaphragm cell process using graphite anodes in chlorine
CONSTITUENT: Carbon tetrachloride

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONISTI EFFECTS
Rat LD_{50} 2800 mg/kg (1) (7) Rat LD_{50} 1770 mg/kg (10)	TLm96: 100-10 ppm (1) LC_{50}: 27.3-125 ppm bluegills LC_{50}: 150 ppm tidewater silversides (2)	Rat LD_{50} 5070 mg/kg (1)	Humans: CNS effects, gastrointestinal upset (10) Humans: fatigue, headache, muscular twitchings, hypoglycemia, jaundice, nausea, diarrhea, anemia, burning of eyes, usually reversible if proper treatment received (2)	Animal positive (1) (2) Human suspected (1)	Indefinite (2) Negative in Ames assay but source said halogenated carbons usually show neg. in that test (2)	Animal positive (2)	BCF: 18 for trout (3) 21-day study bluegill bioconc. CCl_4 to a factor of 30; biological half life in tissues was <1 day; est. weighted ave. bioconc. factor in edible fish/shellfish consumed by Americans: 69 (2)	MOD via oral, in, inhal HIGH via human oral, inhal (10)	Toxicity of CCl_4 potentiated ingestion of alcohol (2)

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
Health: 3 Flamm: 0 React. 0 (9)	Tends to remain indefinitely at bottom of watercourses. (3) Hydrolytic breakdown in water: half-life = 70,000 yrs; accel. by metals such as iron; evaporative half-life in water at ambient temp = 29 minutes (much more significant). (2) Very persistent: persistence in unadapted soil >2 yrs (Cat 5). (4) Adsorption in soil proportional to surface area of clays & organic conent of soils. (3)	Log K_{ow}: 2.6 K_{ow}: 436 (3)	800 mg/l @ 25°C (2) 800 mg/l @ 20°C (3) Insoluble (5) .08 pph @ 20°C (8)	100 mm Hg @ 23.0°C (10) 55.65 mm Hg @ 10°C (2) 91 mm Hg 1.7 psia @ 20°C (3) 40 mm Hg @ 4.3°C 60 mm Hg @ 12.3°C 100 mm Hg @ 23°C 200 mm Hg @ 38.3°C (8)	Odor threshold: 50 ppm (2)	None (10)

TABLE A-9

WASTE: K073 - Chlorinated hydrocarbon wastes from the purification step of the diaphragm cell process using graphite anodes in chlorine

CONSTITUENT: Trichloroethane 1,1,1-

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINO-GENICITY	MUTAGEN-ICITY	TERATO-GENICITY	BIOACCUMU-LATIVITY	SAX RATING	ANTAGONIST EFFECTS
Rat LD_{50} 10,300 mg/kg (1) (3) Rat LD_{50} 14,300 mg/kg (7)	TLm96: 100 - 10 ppm (1) LC_{50}: (freshwater) bluegill: 69.7 mg/1 fathead minnow: 150 mg/1 52.8 mg/1 (marine) sheepshead minnow: 70.9 mg/1 (2)		Human: CNS disorders; animal: CNS effects, cardiovascular system, pulmonary effects & liver & kidney damage (2)	Negative (1) Animal positive (2) Indefinite (1)	No data (2)	No data (2)	BCF: 13 (3) Bluegill: BCF: 9 (2)	MOD via ip, oral (10)	

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBIL-ITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
	Reacts slowly with water, releasing HCl (3) Adsorption in soil proportional to organic content & surface area of clays. (3) Decomposes in water or steam; hydrolysis half-life in light or dark: 6 months; volatility more important than photodegradation. (3)	K_{ow}: 158.5 Log K_{ow}: 2.2 (3)	4400 mg/1 @ 20-25°C 950 ppm (3) Insoluble (5) (8) Low solubility (2)	100 mm Hg @ 20°C 144 mm Hg @ 30°C (3) Half-life in water (evap): 22 min (3) 100 mm Hg @ 20°C (10) 40 mm Hg 1.6°C 60 mm Hg @ 9.5°C 100 mm Hg @ 20.0°C 200 mm Hg @ 36.2°C (8)		None (10

TABLE A-10

WASTE: K073 - Chlorinated hydrocarbon wastes from the purification step of the diaphragm cell process using grapite anodes in chlorine
CONSTITUENT: Tetrachloroethylene

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINO-GENICITY	MUTAGEN-ICITY	TERATO-GENICITY	BIOACCUMU-LATIVITY	SAX RATING	ANTAGONIS EFFECTS
Mouse LD_{50} 8100 mg/kg (1) Mouse LD_{50} 8850 mg/kg (7)	TLm96: 100 - 10 ppm (1) LC_{50}: fathead minnow: 18.4 and 21.4 mg/l bluegill 12.9 mg/l [fresh-water] (2)		Animal: liver, kidney damage, nephropathy. Human: liver, dysfunction, Raynaud's disease, depressed immune function, polymyopathy, acrocyanosis, headache, fatigue, dizziness. (2)	Animal positive (1) (2)	Bacteria positive (2)	Indef. data (2)	Wt avg conc. factor for edible portions of fish & shellfish consumed by Americans: 110 (2) Bluegills BCF: 49, equilibrium reached in 21 days & rapid depuration with half-life <1 day (2)	MOD via inhal, oral, sc, ip, dermal HIGH via iv (10)	Intoleranc alcohol vi tetrachlor ethylene exposure (2)

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBIL-ITY	VAPOR PRESSURE	AESTHETICS	FLAS POIN
Health: 2 Flamm: 0 React: 0 (9)	Moderately persistent, persistence in unadapted soil: 2 - 18 months (Cat 4) (4)	Partition coefficient: 339 (2)	.02 pph @ 20°C (8) 150 ug/ml (2) Essentially insoluble in water (9)	5 mm Hg @ 2.4°C 10 mm Hg @ 13.8°C 20 mm Hg @ 26.3°C 40 mm Hg @ 40.1°C (8) 19 mm Hg (2) 15.8 mm Hg @ 22°C (10)		None (1

TABLE A-11

WASTE: K073 - Chlorinated hydrocarbon wastes from the purification step of the diaphragm cell process using graphite anodes in chlorine
CONSTITUENT: Dichloroethylene 1,1-

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINO-GENICITY	MUTAGEN-ICITY	TERATO-GENICITY	BIOACCUMU-LATIVITY	SAX RATING	ANTAGONISTI EFFECTS
Rat LD$_{50}$ 200 mg/kg (1) Rat LD$_{50}$ 725 mg/kg (7)	TLm96: 1000-100 ppm (1) TLm96: 169 mg/1 fathead minnow 73.9 mg/1 bluegill 249 mg/1 sheepshead minnow 250 mg/1 tidewater silverside (2)		Animals: increased mortality with continuous exposure; no increase with intermittent exposure to the same conc. (2)	Animal positive (1) (2)	Bacteria positive (1) (2) Mammal negative (2)	Animal negative (2)		HIGH carc. via inhal (10)	

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBIL-ITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
Health: 2 Flamm: 4 React: 2 (9)	Non-persistent (12)		2500 mg/1 (2) Not soluble in water (9)	591 mm Hg (2)		0°F 18°C (9) 0°F (ope cup) (10)

TABLE A-12

WASTE: K073 - Chlorinated hydrocarbn wastes from the purification step of the diaphragm cell process using graphite anodes in chlorine

CONSTITUENT: Dichloroethylene 1,2-

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINO-GENICITY	MUTAGEN-ICITY	TERATO-GENICITY	BIOACCUMU-LATIVITY	SAX RATING	ANTAGONISTI EFFECTS
Rat LD_{50} 770 mg/kg (1) (10)	TLm96: 1000-100 ppm (1) LC_{50}: 135 mg/l bluegill (2)		Similar effects to 1,1 but quantitatively less toxic (2) Irritant, narcotic, liver & kidney damage (10)		Bacteria Positive (2)			MOD via oral (10)	

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBIL-ITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
Health: 2 Flamm: 3 React: 2 (9)			6300 mg/1 (2) Not soluble in water (9)	324 mm Hg (2) 400 mm Hg @ 41.0°C (10)		43°F 6°C (9) 39°F (10)

WASTE: K073 - Chlorinated hydrocarbon wastes from the purification step of the diaphragm cell process using graphite anodes in chlorine
CONSTITUENT: Tetrachloroethane 1,1,2,2,-

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONISTI EFFECTS
Rat TDLo 42,000 mg/kg Dog LDLo 300 mg/kg (1) Rat LD$_{50}$ 320 mg/kg (3) Rat LD$_{50}$ 200 mg/kg (10)	TLm96: 21.3 ppm bluegill 12.3 ppm sheepshead minnow (2)	Rabbit LD$_{50}$ 3900 mg/kg (10)	Dogs: liver and kidney damage. Rats and mice: toxic nephropathy. Humans: impaired liver function, depressed immune function, polymyopathy and acrocyanosis. (2) Liver damage, irritation, narcosis. (10)	Animal positive (1) (2)	Bacteria positive (1) (2)	Animal positive (2)	Factor of 8 reported for the bluegill; (2) (3) est. wtd avg bioconc. for edible portions of fish & shellfish consumed by Americans: 18 (2)	HIGH via oral, inhal, MOD via dermal (10)	Intolerance alcohol has reported wit exposure (2)

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
	Very persistent: persistence in unadapted soil: >2 yrs (Cat 5) (4) Known to form azeotropes with water. Half-life: 2 yrs @ pH 7 and 15°C Half-life: 26 days @ pH 7.7 and 15°C (3)	Log: K_{ow}: 2.6 (3)	2900 mg/l 2.9 g/l (2) 2600-4500 ppm (3) Slightly soluble (5) .29 pph @ 20°C (8)	5 mm Hg @ 20.1°C (3) Vol. half-life 21 min (3) 5 mm Hg @ 20.7°C 10 mm Hg @ 33.0°C 20 mm Hg @ 46.2°C (8)	Odor threshold: 5.00 ppm (in water) (3)	Not combustib (11)

Light and Heavy Ends from the Distillation of Acetaldehyde in the Production of Acetic Anhydride

(Not an EPA Listed Waste)

This low volume, low toxicity waste is classified as hazardous because its constituents are highly flammable. The constituents of this waste, which reportedly is produced by four plants which generate on the order of 2,000 tons of waste annually, include methyl acetate, acetone, ethylidene diacetate, and ethyl acetate. Formed as an oxidation by-product, this mildly acidic waste can be biodegraded through composting and landspreading. The flammability characteristics suggest its potential use as a supplemental fuel.

Tables A-14 through 17 provide a summary of various physical, chemical, and toxicological characteristics of the waste constituents.

TABLE A-14

WASTE: Light and heavy ends from the distillation of acetaldehyde in the production of acetic anhydride

CONSTITUENT: Methyl Acetate

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONISTIC EFFECTS
Rat LD_{50} 6970 mg/kg (12)	TLm96: 1000-100 ppm (1)		Irritant 10,000 ppm palpitations of the heart, depression, dizziness (10)					MOD via oral, sc, inhal routes (10)	

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
Health: 1 Flamm: 3 React: 0 (9)			Insoluble (5) 33 pph @ 22°C (8) Water soluble (9)	100 mm Hg @ 9.4°C 200 mm Hg @ 24.0°C 400 mm Hg @ 40.0°C (8) 100 mm Hg @ 9.4°C (10)		14°F -10°C (9) 14°F (10)

TABLE A-15

WASTE: Light and heavy ends from the distillation of acetaldehyde in the production of acetic anhydride

CONSTITUENT: Acetone

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINO-GENICITY	MUTAGEN-ICITY	TERATO-GENICITY	BIOACCUMU-LATIVITY	SAX RATING	ANTAGONISTIC EFFECTS
Rat LD_{50} 9750 mg/kg (1) (10)	TLm96: >1000 ppm (1)	Rabbit LD_{50} 20,000 mg/kg (10)						MOD via oral, ip, inhal VERY LOW via dermal (10)	

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBIL-ITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
Health: 1 Flamm: 3 React: 0 (9)	Low persistence, generally degraded in 1-2 months, category 1 (4)		Soluble in all proportions (5) (8) Water soluble (9)	100 mm Hg @ 7.7°C 200 mm Hg @ 22.7°C 400 mm Hg @ 39.5°C (8) 400 mm Hg @ 39.5 (10)		0°F (close cup) (10) -4°F -20°C (9)

TABLE A-16

WASTE: Light and heavy ends from the distillation of acetaldehyde in the production of acetic anhydride

CONSTITUENT: Ethylidene diacetate

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONISTIC EFFECTS
Rat LD$_{50}$ 3730 mg/kg (1) (10)		Rabbit LD$_{50}$ 500 mg/kg (1) (10)						MOD via oral, dermal, inhal (10)	

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
			Slightly soluble (8)			

TABLE A-17

WASTE: Light and heavy ends from the distillation of acetaldehyde in the production of acetic anhydride

CONSTITUENT: Ethyl acetate

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONISTIC EFFECTS
Rat LD_{50} 11,000 mg/kg (1) (10)	TLm96: 1000-100 ppm		Secondary anemia, leucocytosis, cloudy swelling, fatty degeneration of the viscera (10)					LOW via oral MOD via inhal & ip (10)	

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
Health 1 Flamm: 3 React: 0 (9)			Slightly soluble (5) 8.5 pph @ 15°C (8) Slightly water soluble (9)	40 mm Hg @ 9.1°C 60 mm Hg @16.6°C 100 mm Hg @ 27.0°C 200 mm Hg @42.0°C 100 mm Hg @ 27.0°C (8) (10)		24°F -4°C (9) 24°F (10)

Toxaphene Wastewater Treatment Sludge

EPA Hazardous Waste Identification Number: K041

The production of toxaphene, an acutely toxic chlorinated hydrocarbon pesticide, results in the generation of process wastewater sludges containing concentrations of the pesticide in the range of 1 percent. Approximately 3,750 tons of the waste are reportedly produced annually from two plants in the United States. As a low volume but highly toxic waste, toxaphene sludges have most often been landfilled after treatment with either diatomaceous earth or some other coagulant. This process changes toxaphene sludge from a moderately combustible material to an extremely difficult material to burn.

Biodegradability and stabilization are enhanced by exposure to ozonation and highly aerated composting methods; but the most viable option employed to date is secure landfilling if the site is properly lined and maintained.

Table A-13 summarizes various physical, chemical, and toxicological properties of toxaphene.

TABLE A-18

WASTE: K041 - Wastewater treatment sludge from the production of toxaphene

CONSTITUENT: Toxaphene

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONISTIC EFFECTS
Rat LD$_{50}$ 40 mg/kg (1) Rat LD$_{50}$ 69 mg/kg (3) Rat LD$_{50}$ 60 mg/kg (10)	TLm96: <1 ppm (1) LC$_{50}$: range for fresh-water fish: 0.8 ug/1 Channel catfish to 28 ug/1 goldfish Range for marine fish: 0.5 ug/1 pinfish to 4.7 ug/1 threespine stickleback (2)	Rat LD$_{50}$: 600 mg/kg (1) Rabbit LD$_{50}$: 1025 mg/kg (1) Rat LD$_{50}$: 780 mg/kg (10)	Animals: liver pathology; CNS effects at higher concentrations (2)	Animal positive (1) (2)	Bacteria positive (1)	Animal negative (2)	Brooktrout fry: 76,000 in 15 days Yearling brooktrout: 16,000 in 161 days. Longnose killifish juveniles-29,450 fry-27,900; adults-5,400 (2) Est. wt avg bioconc. factor in edible portions of fish and shellfish consumed by Americans: 18,000 (2) BCG: 491 rainbow trout: 15,000 (3)	HIGH via oral MOD via dermal, inhal (10)	

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
	May dehydrochlorinate upon exposure to sunlight, alkali, or temp. above 120°C; in natural water systems, tends to be absorbed by particulates present or to be taken up by organisms & bioconcentrated; can remain in sediments or absorbed on SS for prolonged periods, although is seldom found in solution in water. (2) Persistent in sediments for long periods of time; transport primarily in sediments; losses from soil may be microbial decomposition, photodecomposition, and/or volatilization; half-life in sandy clay soil is 4 years; soil half-life is 11 years. (3)	Partition coefficient: 825 (2) (3)	0.4-3.0 mg/1 (2) 3 ppm @ 25°C (3)	0.17 - 0.40 mm Hg @ 25°C (2) .2 - .4 mm Hg @ 25°C (3)	Odor threshold = .0052 ppm (3)	115°F TAG closed cup (9)

Distillation Bottoms from the Production of Nitrobenzene

EPA Hazardous Waste Identification Number: K025

Distillation bottoms from nitrobenzene production were listed by EPA for toxicity and contain toxic, mutagenic and carcinogenic organic substances. A low volume, highly toxic waste, distillation bottoms are reportedly generated by seven plants at a combined annual rate of 500 tons. Two substances, meta-dinitrobenzene and 2,4-dinitrotoluene form the basis for its listing. Traditionally landfilled, past problems stress the importance of proper management because each constituent is also highly soluble, persistent, and has migration potential. These wastes were of principal concern at Love Canal, Niagara, NY. Because they resist evaporation, and so lagooning is an inefficient waste reduction method.

Combustion may provide the best disposal alternative, especially if heat recovery is practiced.

Tables A-19 and 20 summarize various physical, chemical, and toxicological properties of the constituents of this waste.

TABLE A-19

WASTE: K025 - Distillation bottoms from the production of nitrobenzene by the nitration of benezene

CONSTITUENT: Meta-dinitrobenzene

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINO-GENICITY	MUTAGEN-ICITY	TERATO-GENICITY	BIOACCUMU-LATIVITY	SAX RATING	ANTAGONISTIC EFFECTS
Rat LD_{50} 30 mg/kg (1) Bird (wild) LD_{50} 42 mg/kg (1) (10)	Lethal concs. minnows: 10-12 mg/l (distilled H_2O) Fish: 2 mg/l (all unspecified isomers of dinitrobenzene) (2)	Man TDLo 4 mg/kg (1)	Most potent methemoglobin-forming agent of the nitroaromatics (2)	No data (2)	Bacteria positive (1) Positive for dinitrobenzene metabolite dinitrophenol; no data on dinitrobenzene (2)	Sea urchin positive for dinitrophenol; no effects on animal; no data on dinitrobenzene (2)	Low bioconc. potential (2)	HIGH via oral (10)	Symptoms potentiated by exposure to sunlight or ingestion of alcohol (2)

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
(Ortho listed) (9)	(Para-biodegradation by a soil innoculium in >64 days; degradation: 0) (3) Stable in neutral aqueous solutions; as medium becomes more alkaline they hydrolyze Biodegradation by acclimated microorganisms (2)	K_{ow}: $10^{1.62}$ (3)	.3 parts/100 parts H_2O (3) Insoluble (5) .3 pph @ 99°C (8)	Volatile with steam (3)		

TABLE A-20

WASTE: K025 - Distillation bottoms from the production of nitrobenzene by the nitration of benezene

CONSTITUENT: 2,4-dinitrotoluene

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONISTI EFFECTS
Rat LD_{50} 268 mg/kg (1) (10) Rat LD_{50} 707 mg/kg (7)	TLm96: 100 - 10 ppm (1) TLm96: fathead minnow: 31 mg/1 (2)		Human, animals: liver damage, jaundice, methemoglobinemia, reversible anemia with reticulocytosis (2) Irritant, allergen (10)	Animal positive (1) (2)	Bacteria, animal positive (2)	No data (2)	Est. wt avg bioconc. factor for edible portions of fish & shellfish consumed by Americans: 5.5 (2) 19 (2)	HIGH via oral, inhal dermal 10)	Alcohol has synergistic effect on toxicity (2)

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
Health* 2 3 Flamm: 1 React: 3 (9) [*two different values were quoted in one source]	(2,6-) (Moderately persistent: persistence in unadapted soil: 3-18 months - Cat 4) (4) Relatively stable at ambient temperatures (2)		Insoluble (5) .03 pph @ 22°C (8) 270 mg/1 @ 22°C (2) Very slightly soluble in H_2O Soluble in alcohol & ether (12)			404°F (9) 404°F (10)

Spent Stripping and Cleaning Bath Solutions from Electroplating Operations Where Cyanides are Used in the Process (Except for Precious Metals Electroplating Spend Stripping and Cleaning Bath Solutions)

EPA Hazardous Waste Identification Number: F009

A low volume, high toxicity waste, spent stripping and cleaning bath solutions contain either cyanide salts or complexed cyanide compounds. Approximately 22,500 gallons of this toxic and reactive waste are generated annually from 10,000 domestic production sites. These solutions are generally disposed on a quarterly basis.

Cyanide salts and complexed cyanides present in spent electroplating stripping and cleaning bath solutions may migrate from the waste in aqueous solution or as gaseous hydrogen cyanide. A reactive substance, hydrogen cyanide gas is produced upon exposure to slightly acidic conditions. Alkaline chlorination of the wastewater destroys most cyanide compounds, but does not destroy complexed cyanides which become entrained in the sludge produced in wastewater treatment. Due to the inorganic nature of the sludge, it is neither biologically treatable, nor combustible. Wastes can be evaporated and residue disposed in a pH controlled secure landfill situation. Wet wastes can be deep well injected. Metal recovery has been practiced.

Tables A-21and 22 provide a summary of various physical, chemical, and toxicological characteristics of the cyanide salts present in this waste.

TABLE A-21

WASTE: F009 - Spent stripping and cleaning bath solutions from electroplating operations where cyanides are used in the process (except for precious metals electroplating spend stripping and cleaning bath solutions)

CONSTITUENT: Cyanide salts, Sodium cyanide

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINO-GENICITY	MUTAGEN-ICITY	TERATO-GENICITY	BIOACCUMU-LATIVITY	SAX RATING	ANTAGONISTI EFFECTS
Rat LD_{50} 6.44 mg/kg (1) (10) Rat LD_{50} 15 mg/kg (12)	TLm96: bluegill: 0.28 mg/l (12)						Not bio-accumulative	HIGH via oral, ip, sc, iv Toxic via dermal (10)	

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBIL-ITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
Health: 3 Flamm: 0 React: 0 (9)	Not persistent (12)		48 g/100 cc @ 10°C 82 g/100 cc @ 35°C (5) 48 pph @ 10°C 82 pph @ 35°C (8)	1mm Hg @ 817°C (8) (10)		

TABLE A-22

WASTE: F009 - Spent stripping and cleaning bath solutions from electroplating operations where cyanides are used in the process (except for precious metals electroplating spent stripping and cleaning bath solutions)
CONSTITUENT: Cyanide salts, Potassium cyanide

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONISTIC EFFECTS
Rat LD_{50} 10 mg/kg (1) (10)	TLm96: <10 ppm (1)				Animal positive (1)			HIGH via oral, ip, sc Toxic via dermal (10)	

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
Health: 3 Flamm: 0 React: 0 (9)			Cold water; 50 g/100 cc hot water; 100 g/100 cc (5) Soluble in cold water; 122.2 pph @ 103.3°C (8)			

Wastewater Treatment Sludge from the Production of Titanium Dioxide Pigment Using Chromium-Bearing Ores by the Chloride Process

EPA Hazardous Waste Identification Number: K074

Delisted as of 30 October 1980, this waste is a low toxicity, high volume waste that was listed because it was suspected to contain the toxic metal chromium in both the trivalent and the hexavalent states. This waste is one of only a few chromium bearing wastes to be delisted because industry successfully proved to the EPA that the waste contains chromium only in the trivalent state. Production sites reportedly generate 900,000 tons of this waste per year.

Typical treatment consists of calcination, recycling, precipitation, filtration and evaporation. Wastes may also be disposed by deep well injection and careful land disposal at secure sites. The landspreading must be carefully conducted to avoid excessive elemental buildup and pH must be strictly controlled. Case studies suggest that this waste is merely stockpiled onsite in some instances with management provisions to prevent the release of fugitive emissions from the dried sludge.

Tables A-23 through 25 provide a summary of various physical, chemical, and toxicological characteristics of chromium in both the trivalent and hexavalent states. Cr_2O_3 and $CrCl_3$ are the major forms of trivalent chromium found in the waste. Hexavalent chromium, though present in only minute amounts, may be the most hazardous constituent of the waste.

TABLE A-23

WASTE: K074 - WWTS from the production of TiO_2 pigment using chromium-bearing ores by the chloride process.

CONSTITUENT: Chromium (trivalent - $CrCl_3$)

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONISTIC EFFECTS
Rat LD_{50} 1870 mg/kg (1) (3) (10)	Trivalent: TLm 96: 11 species of fresh-water fish: 3.33-71.9 mg/l guppy most sensitive; bluegill most resistant (2) (range of hardness)	Guinea Pig LD_{50}: 202 mg/kg (10)	Chronic effects: ulcerative changes & allergic contact dermatitis. (2) Chronic action on the skin and mucous membranes, lesions, ulcers on the skin. (10)	Trivalent: no carcinogenic effects (2) Animal suspect (1) Human indefinite (1)	Trivalent: bacteria negative (2)	Hexavalent and trivalent: indefinite (2)	Potassium chromate: rainbow trout: 1 3 species of bivalve molluscs: 34 166 152 (2)	HIGH via dermal MOD via oral (10)	

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER PART. COEFF.	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
	Trivalent: more likely to accumulate in sediments. (2) Precipitated as hydrous oxide and disappears from water column; retained by clays; soil pH is the major determinant of uptake. (3) May last indefinitely in insoluble form. (3)		Insoluble in water. (2) Insoluble in cold water; (5) Soluble in hot water. (8)	Cr: 1 mm Hg @ 1616°C (8)	Taste threshold: 1.4 ppm (lower) 25 ppm (upper) (3)	

TABLE A-24

WASTE: K074 - WWTS from the production of TiO_2 pigment using chromium-bearing ores by the chloride process.

CONSTITUENT: Chromium (hexavalent)

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONISTIC EFFECTS
	TLm96: freshwater 17.6 mg/l fathead minnow (soft water) 195 mg/l large mouth bass (hard water) marine 30 mg/l speckled sand dab 91 mg/l mummichog (2)		Chronic effects: ulcerative changes & allergic contact dermatitis—no disc. of reversible etc. (2) Corrosive action on the skin and mucous membranes, lesions, ulcers on the skin (10)	Animal positive human suspected (2)	Bacteria positive (1) human positive (2)	Hexavalent and trivalent: indefinite (2)	Potassium chromate: rainbow trout: 1 3 species of bivalve molluscs: 34 166 152 (2)	CrO_3 chromic acid: VERY HIGH via inhal (10)	

PHYSICAL						
NFPA	PERSISTENCE	OCT/WATER	SOLUBLE	VAPOR PRESSURE	AESTHETICS	FLASH POINT
	Water-soluble remains indefinitely in the environment in some form. (2) Hexavalent (+6) does not precipitate at any enviromental pH uless reacted with Ba; is reduced to Cr^{+3} in presence of soil and organic matter. (3)	K_{ow}: 1 (3)	Soluble in water (2)	Cr: 1mm Hg @ 1616°C (8)	Taste threshold: 1.4 ppm (lower) 25 ppm (upper) (3)	

TABLE A-25

WASTE: K074 - WWTS from the production of TiO_2 pigment using chromium-bearing ores by the chloride process.

CONSTITUENT: Chromium (trivalent - Cr_2O_3)

TOXICITY

ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONISTIC EFFECTS
	Trivalent: TLm 96: 11 species of fresh-water fish: 3.33-71.9 mg/l guppy most sensitive; bluegill most resistant (2) (range of hardness)		Chronic effects: ulcerative changes and allergic contact dermatitis (2) Corrosive action on the skin and mucous membranes, lesions, ulcers on the skin. (10)	Animal suspected (1)	Trivalent: bacteria negative (2)	Hexavalent and trivalent: indefinite. (2)	Potassium chromate: rainbow trout: 1 3 species of bivalve molluscs: 34 166 152 (2)	HIGH via inhal (10)	

PHYSICAL

NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
	Trivalent: more likely to accumulate in sediments. (2) Precipitated as hydrous oxide and disappears from water column; retained by clays, soil pH is the major determinant of uptake. (3) May last indefinitely in soluble form		Insoluble in water. (2) Insoluble in cold water. (8) Slightly soluble in hot water. (5)	Cr: 1mm Hg @ 1616°c (8)	Taste threshold: 1.4 ppm (lower) 25 ppm (upper) (3)	

Ammonia Still Lime Sludge from Coking

EPA Hazardous Waste Identification Number: K060

Ammonia still lime sludge from coking is listed because for toxicity. A low volume, high toxicity waste, ammonia is obtained in chemical by-product recovery from cokemaking by the addition of lime to the waste liquor for pH adjustment prior to ammonia stripping. Formerly over 30 plants produced nearly 1,000,000 tons each year. In recent years this process has been phased out and only two companies and a few facilities currently generate this waste. The lime sludge produced contains the hazardous constituents cyanide, naphthalene, phenol, and arsenic which can contaminate the environment from uncontrolled discharge to land. Secure land disposal techniques are the most suitable for this waste. As a lime sludge, it has poor incineration potential. While components such as phenol and naphthalene are biologically treatable, and cyanides are chemically destructable, difficult of separating constituents from the mixture reduces treatment potential due to cost. Although the sludge may have potential in a neutralization process, the arsenic contamination limits application.

Tables A-26 through 31 summarize the physical, chemical, and toxicological properties of the waste constituents.

TABLE A-26

WASTE: K060 - Ammonia still lime sludge from coking

CONSTITUENT: Cyanide

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONISTIC EFFECTS
	LC$_{50}$: 52 μg/l: juvenile brook trout 507 μg/l: sac fry brook trout (2)		Repeated sublethal doses do not result in cumulative adverse effects (2) Chronic effect level conc. in freshwater fish (2)	No data (2)	No data (2)	Not known, although thiocyanate-the major metabolic product of CN *in vivo* (2)	2.3 (2)		Cyanide poisoning is antagonized by any chemical agent capable of rapidly generating methemoglobin *in vivo* such as sodium nitrate or other aromatic nitro and amino compounds

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
				0m @ 20C mm Hg (11)		Not combustible (11)

TABLE A-27

WASTE: K060 - Ammonia still lime sludge from coking

CONSTITUENT: Naphthalene

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINO-GENICITY	MUTAGEN-ICITY	TERATO-GENICITY	BIOACCUMU-LATIVITY	SAX RATING	ANTAGONISTIC EFFECTS
Rat LD_{50} 1780 mg/kg (1) (7) (10)	TLm96: 10 - 1 ppm (1) TLm96: 150 mg/l mosquitofish (freshwater) 2.4 mg/l sheepshead minnow (marine) (2)		Animals: cataracts, retinal changes, jaundice, renal disease (2) Nausea, headache, hematuria, fever, anemia, liver damage, coma convulsions (10)	Animal uncertain (2)	Bacteria negative (2)	No data (2)	Est. wt.avg. conc. factor for edible portions of fish & shellfish consumed by Americans: 60 (2) Aquatic orgs with 8% lipid content: 210 Marine inverts: copepod: 50-60 (1 day) 5,000 (nine days) 32-77 1-24 hrs for 3 species fish & 1 species of mussel (2)	MOD via oral HIGH via ip (10)	

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBIL-ITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
Health: 2 Flamm: 2 React: 0	Difficult to degrade biologically: persistence in unadapted soil: 3 months: 1 year (Cat 3) (4)	Partition Coefficient: 2300 (2)	30 - 40 μg/l (2) Insoluble (5) .003 pph @ 25°C Not soluble in water (9)	.0492 mm Hg @ 19.8°C (2) 1 mm Hg @ 52.6°C (8) (10)		174°F 79°C (9) 174°F (closed cup) (10)

TABLE A-28

WASTE: K060 - Ammonia still lime sludge from coking

CONSTITUENT: Phenol

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONISTI EFFECTS
Rat LD_{50} 414 mg/kg (1) (10) Rat LD_{50} 530 mg/kg (3) Rat LD_{50} 350-530 mg/kg (12)	TLm96: 100 - 10 ppm (1) TLm96: freshwater fish (13 species) range: 5.02 mg/l (rainbow trout) to 200 mg/l (goldfish) marine: 5.2 mg/l (rainbow trout) to 6.014 mg/l (mountain bass) (2)	Rabbit LD_{50} 850 mg/kg (1) Rat LD_{50} 669 mg/kg (10)	Humans: liver damage. Animals: kidney, liver damage; depressed weight gain (2) CNS effects, digestive disturbances (10)	Animals positive human: one case documented (2)	Bacteria positive (2)		Est. wt.avg. bioconc. factor for edible ports. of fish and shellfish consumed by Americans: 2.3 (2) (3) Measured BCF for goldfish of 1.2 to 2.3 (2) BCF: 8 (3)	HIGH via oral, ip, sc, dermal (10)	

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
Health: 3 Flamm: 2 React: 0 (9)	In presence of earth and aquatic plants-phenol will decompose 3-5 ppm/day with accompanying decrease in DO (3) Not persistent-decomposes in soil without leaving residues; readily biodegradable (12)	Log K_{ow}: 1.5 (3)	67,000 mg/l @ 16°C (2) (3) Soluble in all proportions in hot water (5) 8.2 pph @ 15°C (8) Water soluble (9) Soluble in all propor- at 66°C (2)	.35 mm Hg @ 25°C (2) (3) 20 mm Hg @ 86°C (3) Evap. rate: .00052 cm/m (3) 1 mm Hg @ 40.1°C (8) (10)	Odor threshold: .016 - 16.7 ppm Taste threshold: .0001 (3)	175°F 79°C (9) 175°F (closed cup) (10) 85°C (open cup) 79°C (closed cup) (2)

TABLE A-29

WASTE: K060 - Ammonia still lime sludge from coking

CONSTITUENT: Arsenic

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONISTIC EFFECTS
Mouse TDLo 120 mg/kg (preg) (1) Rat LD_{50} 15 mg/kg (3)	TLm96: 1-10 ppm (acid) (12)		Human: hyperkeratosis, blackfoot disease, liver damage, cardiovascular disease susceptibility, neurological disturbances, effects on hematopoietic system and reduced resistance to viral infections (2)	Indef. (1) Human suspected Animal studies negative (2)	Arsenicals and arsenate; bacteria, animal, human positive although +5 and +3 bacteria negative Total: indef. (2)	Animal positive (2)	Est. wt avg bioconc. factor for edible ports. of fish and shellfish consumed by Americans: 2.3 (2) BCF for 5 freshwater invertebrate and 2 fish species ranged from <1 to 17 (2) 13,000: oysters; 8,600: lobsters; 27,000: crabs; 23,000: mussels; half-life in total human body is 280 days. (3)	HIGH via im, sc (10)	

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
	$AsO_4^{=}$most stable form in aerated water; As° & AsH_3 can exist in very reducing sediments (3) Arsenic will persist in some form in the environment (2) +5 form is favored thermodynamically under normal conditions in water and is more soluble than +3 form (2) Waters containing high organic matter may bind As compounds to colloidal humic matter (2) As strongly held by soils & long in moving through soil column; arsenate anions among the few anions that appear to be held by natural exchange (3) Very persistent; changes forms readily to move easily through the water column until consumed (3)	K_{ow}: 1 (3)	Arsenic is insoluble but salts are quite soluble (3) Insoluble (8)	1 mm Hg @ 372°C (8) (10)		

TABLE A-30

WASTE: K060 - Ammonia still lime sludge from coking

CONSTITUENT: Arsenic Pentoxide

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONISTIC EFFECTS
Rat LD_{50} 8 mg/kg (1) (10)	TLm96: 10 - 1 ppm (1)		Human: hyperkeratosis, blackfoot disease, liver damage, cardiovascular disease susceptibility neurological disturbances, effects on hematopoietic system and reduced resistance to viral infections (2)	Indef. (1) Positive (10) Human Positive (1)	Arsenicals and arsenate: bacteria, animal, and human positive, although +5 and +3, bacteria negative Total: indef. (2)	Animal positive (2)	Est. wt.avg. bioconc. factor for edible ports. of fish and shellfish consumed by Americans: 2.3 (2) BCF for 5 freshwater invertabrate and 2 fish species ranged from <1 to 17 (2) 13,000: oysters; 8,600: lobsters; 27,000: crabs; 23,000: mussels half-live in total human body is 280 days (3)	HIGH via oral, iv (10)	

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
	AsO_4=most stable form in aerated water; As^0 & Ast_3 can exist in very reducing sediments (3) Arsenic will persist in some form in the environment (2) +5 form is favored thermodynamically under normal conditions in water and is more soluble than +3 form (2) Waters containing high organic matter may bind As compounds to colloidal humic matter (2) As strongly held by soils & long in moving through soil column; arsenate anions among the few anions that appear to be held by natural exchange (3) Very persistent; changes forms readily to move easily through the water column until consumed (3)	K_{ow}: 1 (3)	150 g/100 cc @ 16°C 76.7 g/100 cc @ 100°C (5) 2300×10^3 mg/1 @ 20°C (2) 59.5 pph @ 0°C 76.7 pph @ 100°C (8)		Dissolves in water to form arsenic acid H_3AsO_4 (2)	

TABLE A-31

WASTE: K060 - Ammonia still lime sludge from coking

CONSTITUENT: Arsenic Trioxide

TOXICITY									
ORAL	AQUATIC	DERMAL	CHRONIC	CARCINOGENICITY	MUTAGENICITY	TERATOGENICITY	BIOACCUMULATIVITY	SAX RATING	ANTAGONISTI EFFECTS
Rat LD_{50} 20 mg/kg (1) (10)	TLm96: 10 - 1 ppm (1)		Human: hyperkeratosis, blackfoot disease, liver damage, cardiovascular disease susceptibility neurological disturbances, effects on hematopoietic system and reduced resistance to viral infections (2)	Human suspected (1) Human positive (10) Human positive (1)	Arsenicals and arsenate; bacteria, animal, and human, positive, although +5 and +3 bacteria negative Total: indef. (2)	Animal positive (2)	Est. wt. avg. bioconc. factor for edible ports. of fish and shellfish consumed by Americans: 2.3 (2) BCF for 5 freshwater invertebrate and 2 fish species ranged from <1 to 17 (2) 13,000: oysters; 8,600: lobsters; 27,000: crabs; 23,000: mussels; half-life in total human body is 280 day (3)	HIGH via oral, sc (10)	

PHYSICAL						
NFPA RATING	PERSISTENCE	OCT/WATER	SOLUBILITY	VAPOR PRESSURE	AESTHETICS	FLASH POINT
	AsO_4=most stable form in aerated water; As^0 & Ast_3 can exist in very reducing sediments (3) Arsenic will persist in some form in the environment (2) +5 form is favored thermodynamically under normal conditions in water and is more soluble than +3 form (2) Waters containing high organic matter may bind As compounds to colloidal humic matter (2) As strongly held by soils & long in moving through soil column; arsenate anions among the few anions that appear to be held by natural exchange (3) Very persistent; changes forms readily to move easily through the water column until consumed (3)	K_{ow}: 1 (3)	1.2 g/100 cc @ 2°C 3.7 g/100 cc @ 20°C 11.46 g/100 cc @ 100°C 10.14 g/100cc cc @ 100°C (5) 12×10^3 mg/1 @ 0°C 21×10^3 mg/1 @ 25°C (2) 1.21 pph @ 0°C 2.93 pph @ 40°C Slightly soluble (8)	1 mm Hg @ 212.5°C (8)	Dissolves in water to form arsenious acid H_3AsO_3 (2)	

REFERENCES FOR TABLES A-1 TO 31 OF PHYSICAL, CHEMICAL AND TOXICOLOGICAL PROPERTIES OF HAZARDOUS WASTE CONSTITUENTS

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3. "EPA Hazardous Waste Listing Background Documents - Appendix B

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APPENDIX B

INDUSTRIAL FACILITY PROFILES

Tables B-1 to B-14 contain industrial facility profiles for those industries participating in the study survey through October 1981.

TABLE B-1

INDUSTRIAL FACILITY PROFILE

1. Waste stream: K071
   Brine purification muds from the mercury cell process in chlorine production where separately prepurified brine is not used.

2. Facility code: K071.1 (a chemical manufacturer)

3. Quantity generated: Annually: 5480 tons
   Daily: 15 tons

4. Concentration of constituents of concern:
   Mercury: Average: 70 ppm
   Range: 7 ppm - 230 ppm

5. Waste pH: (when mixed with equal weight of H_2O): 9 - 11

6. Flash point: N/A

7. Radioactivity: N/A

8. Management procedures for case study waste:

   Basic Management Steps

   1. Sludge is trucked to one corner of surface impoundment.
   2. Wastewaters are slurried to another corner of the impoundment.
   3. Some sludge is slurried to wastewater occupied section of the impoundment.
   4. Wastes are treated with acid and sulfide to precipitate the mercury.
   5. Wastewater is pumped through a filter and piped to another pond.
   6. Sludge remains

9. Other wastes undergoing same treatment, storage, and disposal procedures:
   (183,000 t/yr): D002 (corrosive mercury-containing wastes) and
   D009 (EP toxic mercury-containing wastes).

10. Waste segregation: All organic wastes are segregated from mercury-laden wastes because the organics interfere with the mercury precipitation.

11. Case study waste management history: No major changes in management practices have been implemented.

12. Case study waste management plans: The managers may submit a delisting petition for K071.

13. Landfill characteristics: A 25 foot native clay liner underlies the landfill. Groundwater is monitored for mercury contamination four times annually.

14. Additional costs associated with RCRA requirements: No major costs have been incurred because of RCRA.

TABLE B-2

INDUSTRIAL FACILITY PROFILE

1. Waste stream: K071
   Brine purification muds from the mercury cell process in chlorine production where separately prepurified brine is not used.

2. Facility code: K071.2 (a chemical manufacturer)

3. Quantity generated: Annually: 11,000 tons
   Daily: 30.5 tons

4. Concentration of constituents of concern:
   Mercury: 10 - 60 ppm

5. Waste pH (when mixed with equal weight of H_2O): 8 - 9

6. Flash point: N/A

7. Radioactivity: N/A

8. Management procedures for case study waste:

   Basic Management Steps
   1. Waste is stored in the ground in a concrete tank.
   2. Brine from the liquid waste is collected after rock salt and gypsum settle out.
   3. Settled materials are blown down.
   4. Liquid is decanted and reused in the industrial process.
   5. Dewatered material is stacked on an apron around the top of the storage tank.
   6. These materials are trucked to a landfill designed to surpass RCRA requirements.

9. Other wastes undergoing same treatment, storage, and disposal procedures:

   U151 - mercury containing (20 tons/yr)
   D009 - mercury containing (65 tons/yr)
   K106 - waste water treatment sludge from the mercury cell process process of chlorine production (listed for mercury)

10. Waste segregation: All wastes containing available chlorine are carefully segregated from mercury containing wastes because chlorine aggressively solubilizes mercury.

11. Case study waste management history: Prior to RCRA wastes were disposed in solid waste landfill onsite.

12. Case study waste management plans: The company is trying to delist K071 for this facility. If they are successful they will not construct the remaining 4/5 of their secure landfill. Rather they will dispose K071 in a sanitary landfill at about half cost. They are currently disposing in the one completed cell of this facility and have designed four additional cells.

TABLE B-2

(continued)

13. Landfill characteristics:
    Capacity: 16,000 cubic yards
    Cell size: 100' x 300' x 30'; sufficient for three years material storage at present rate of waste generation.
    Planned expansion: to 500 x 300 x 30' (15 year storage capacity at present disposal rate).
    Environmental protection features: double liner; leachate detection system between liners; and leachate collection system.

14. Additional costs associated with RCRA requirements:
    Capital cost for cell #1: $1,000,000
    Hydrogeological study for landfill: $85,000
    Landfill operator: $32,000/yr

TABLE B-3

INDUSTRIAL FACILITY PROFILE

1. Waste stream: K071
   Brine purification muds from the mercury cell process in chlorine production where separately pre-purified brine is not used.

2. Facility code: K071.3 (a chemical manufacturer)

3. Quantity generated:
   Annually: 907 tons dry; 1,350 tons wet; 2257 tons total
   Daily: 2.5 tons dry; 3.75 tons wet; 6.25 tons total

4. Concentration of constituents of concern:
   Mercury: 10 - 60 ppm

5. Waste pH (when mixed with an equal weight of H_2O): 8 - 9

6. Flash point: N/A

7. Radioactivity: N/A

8. Management procedures for case study waste:

   Basic Management Steps
   1. Dry wastes are sent to one facility and wet wastes are sent to another.
   2. In wet waste situation the settled material is filtered.
   3. Filters and filter backwash are air dried and disposed in solid waste landfill.
   4. Settled muds are hydraulically conveyed as a slurry to landfill.
   5. Brine is decanted and piped back to the plant.
   6. Sludge remains

9. Other wastes undergoing same treatment, storage, and disposal procedures:
   D009: Mercury containing waste (19 tons/yr)
   K106: Wastewater treatment sludge from the mercury cell process of chlorite production - listed for mercury (128 tons/yr)

10. Case study waste management history: Waste management practices have not changed.

11. Case study waste management plans: No major changes in waste management procedures are anticipated.

12. Landfill characteristics: Both landfills receiving K071 are underlain with single synthetic membrane liners.

13. Additional costs associated with RCRA requirements:
    No major costs have been incurred as a result of RCRA.

TABLE B-4

INDUSTRIAL FACILITY PROFILE

1. Waste stream: K013
   Bottom streams from the acetonitrile column in the production of acrylonitrile.

2. Facility code: K013.1 (a chemical manufacturer)

3. Quantity generated: (This waste is over 99% water)
   Annually: 396,000 tons
   Daily: 1,182 tons

4. Concentration of constituents of concern:

Acetonitrile:	10-100 ppm
Acrylonitrile:	10-100 ppm'
Hydrocyanic acid:	50-300 ppm

5. Waste pH: 5.5 - 6

6. Flash point: N/A

7. Radioactivity: N/A

8. Management procedures for case study waste:

   Basic Management Steps
   1. Waste is pretreated by a proprietary method to "detoxify the hydrocyanic acid".
   2. This treated wastewater is not stored onsite but is discharged directly to the municipal sewer system.
   3. Only spills or "process upsets" require material storage onsite, in which case materials may be incinerated onsite.

9. Other wastes undergoing same treatment, storage, and disposal procedures:
   K014: Bottoms from the acetronitrile purification column in the production of acrylonitrile (44,000 tons annually). Listed for acrylomide and acetonitrile. Also, storm water and wash water may be treated in combination with K014 and K013.

10. Waste segregation: Wastes from the production of acrylonitrile are segregated from all other wastes produced on site.

11. Case study waste management history: No major changes in waste management procedures have been initiated.

12. Case study management plans: No major changes in waste management procedures are anticipated although the plant has initiated administrative steps toward RCRA compliance.

TABLE B-4

(continued)

13. Additional costs associated with RCRA requirements: No significant costs have been incurred as a result of RCRA hazardous waste management requirements.

TABLE B-5

INDUSTRIAL FACILITY PROFILE

1. Waste stream: K013
   Bottom stream from the acetonitrile column in the production of acrylonitrile.

2. Facility code: K013.2 (a chemical manufacturer)

3. Quantity generated annually: 360,000 tons

4. Concentration of constituents of concern:

Acetonitrile:	10-100 ppm
Acrylonitrile:	10-50 ppm
Hydrocyanic acid:	50-200 ppm

5. Waste pH: 6 - 7

6. Flash point: N/A

7. Radioactivity: N/A

8. Management procedures for case study waste: Waste is clarified, stored, filtered and disposed in waste disposal wells.

9. Other wastes undergoing same treatment, storage and disposal procedures:
   K011 (410,000 tons/year): Bottom stream from the wastewater stripper in the production of acrylonitrile.
   K014 (300 tons/year): Bottoms from the acetonitrile purification column in the production of acrylonitrile.
   Contaminated storm and washwater are also managed with K013.

10. Case study waste management history: Additional operator training inspections, labeling and record keeping have recently been implemented to comply with RCRA requirements.

11. Case study waste management plans: No major changes are anticipated.

TABLE B-6

INDUSTRIAL FACILITY PROFILE

1. Waste Stream: K073
   Chlorinated hydrocarbon wastes from the purification step in the diaphragm cell process using graphite anodes in chlorine production

2. Facility Code: K073.1 (a chemical manufacturer)

3. Quantity Generated: Annually - 30 pounds

4. Concentration of constituents of concern:
   (This waste is listed for the following constituents:)

chloroform	44 ppb
carbon tetrachloride	109 ppb
hexachloroethane	6 ppb
trichloroethane	0
tetrachloroethylene	15 ppb
dichloroethylene	11 ppb
1,1,2,2-tetrachloroethane	0

(The following constituents are also detectable:)

methylene chloride	2 ppb
hexachlorobutadiene	32 ppb
trichloroethylene	0.3 ppb

5. Waste pH: 1-2 at process area
   approx. 12: when mixed with a caustic waste stream disposed in the same surface impoundment

6. Flash point: N/A

7. Radioactivity: N/A

8. Management procedures for case study waste:

   Basic Management Steps

   (1) Waste stream (chlorine condensate) is piped from plant to 14 acre surface impoundment/solar evaporation pond on site.
   (2) The stream is mixed with a caustic (pH 10-12) process stream in the impoundment.
   (3) When this evaporation pond is filled, the company will close it and construct another.

9. Other wastes undergoing same treatment, storage, and disposal procedures:

   F001: Spent halogenated solvents containing carbon tetrachloride - 10 lb/yr
   D001: Ignitable solvents - 50 lbs/yr
   D002: Corrosive liquids - 450 x 10^6 lbs/yr

10. Waste Segregation:
    No significant waste incompatabilities characterize the waste streams generated at this facility

TABLE B-6

(continued)

11. Case study waste management history:
Aside from additional recordkeeping, no changes in waste management procedures have been implemented in response to RCRA requirements.

12. Case study waste management plans:
No waste management changes are anticipated.

13. Landfill characteristics:
Landfill is underlain with 1-2 ft. thick clay liner and has no leachate collection system.

14. Additional costs associated with RCRA requirements:
No major costs have been incurred as a result of RCRA requirements. If the facility is required to implement a groundwater monitoring program, the associated costs are expected to be in the range of $100,000.

TABLE B-7

INDUSTRIAL FACILITY PROFILE

1. Waste stream: K041
   Wastewater treatment sludge from the production of toxaphene

2. Facility code: K041.1 (a chemical manufacturer)

3. Quantity generated: Annually: 200 tons
   Daily: 0.55 - 1 ton

4. Concentration of constituents of concern:
   Toxaphene: Average: 0.75% by weight
   Range: 0.5 - 1% by weight

5. Waste pH: (when mixed with equal weight of H_2O) 6.5 - 7

6. Flash Point: N/A

7. Radioactivity: N/A

8. Management procedures for case study waste:

   Basic Management Steps
   1. pH of wastewater is adjusted in process area
   2. Wastewater is stored and dried in two basins (one "operating into" basin; one drying basin).
   3. Resulting sludge is trucked offsite to company-owned, state approved landfill.

   Waste Management Description
   The toxaphene process wastewater is acidic. Sodium hydroxide is used, in the process area, to neutralize the wastewater. This neutralized wastewater is held in two settling basins and lime is added to adsorb the toxaphene. The toxaphene precipitates, adsorbed on the lime, and the resulting sludge is dried. This dried sludge is trucked five miles to the landfill. This procedure is routine and does not vary.

9. Other wastes undergoing same treatment, storage, and disposal procedures: K098: untreated process wastewater (treated = 1.5 ppb toxaphene).

10. Waste segregation: All chlorine bearing wastes are carefully segregated from toxaphene containing wastes. (Only wastes containing toxaphene undergo same treatment, storage, and disposal.)

11. Case study waste management history: Prior to the construction of the landfill. wastes were stored onsite in open piles.

12. Case study waste management plans: The landfill is full and will be closed. In the future, wastes will be disposed in a secure commercial landfill. Onsite waste piles from pre 1975 operations will (eventually) be excavated, removed and disposed.

TABLE B-7

(continued)

13. Landfill characteristics:
    Underlain with Bentonite clay liner
    Groundwater monitoring: 6 wells, 4 times/yr
    No leachate collection system

14. Plant characteristics:
    Unlined basins
    Routine sampling
    Rainwater collection system

15. Additional costs associated with RCRA requirements: Most costs associated with environmental regulation were incurred because of Clean Water Act provisions. Examples include:
    - Installation of rainwater collection system: $1/2 million
    - Installation of amberlite resin absorption system for tertiary treatment: $1/2 million
    - Annual costs of amberlite system: maintenance: $40,000

    RCRA related costs:
    - Potential cost of $1/2 million for disposing sludge generated before 1975.
    - Investigation and monitoring: $25,000 annually
    - Anticipated closure costs for landfill: $1000/mo for 30 years of inspection and reporting

TABLE B-8

INDUSTRIAL FACILITY PROFILE

1. Waste Stream: K041
   Wastewater treatment sludge from the production of Toxaphene*.

2. Facility code: K041.2 (a pesticide manufacturer)

3. Quantity generated: Annually - 20,736,000 gallons
   This figure includes the following wastes:
   - P020 (2-sec-Butyl-4,6-dinitrophenol)
   - U224 (Toxaphene)
   - U239 (Xylene)

4. Concentration of constituents of concern:
   Toxaphene - 1.5 ppb in treated wastewater
   Dinitrobutyl phenol - .4 ppm in treated wastewater; as high as 20 ppm in pond

5. Waste pH: 6-9 (after being adjusted with sodium hydroxide)

6. Flash point: N/A

7. Radioactivity: N/A

8. Management procedures for case study waste:
   (1) Three types of toxaphene-containing wastes are generated at this facility. One consists of contaminated clothing and other materials or residues from cleaned-up spills. This material is stored in coated, sealed metal drums and disposed by a private licensed disposal company. This material is not included in the "quantity generated" value presented above in Item 3.
   (2) The second type of waste is that liquid collected by the rainwater collection system. This runoff is collected and discharged directly to a waterway without treatment. This waste is not included in the "quantity generated" value presented above in Item 3.
   (3) The third category of waste is the wastewater from pesticide production. These wastes are stored on-site in an unlined pond, treated through activated carbon filtration, and discharged to a waterway in accordance with an NPDES permit.

9. Waste management history: No major waste management changes have been implemented.

10. Waste management plans: No major waste management procedures are anticipated.

---

* This facility filed a notification form including K041 as one of its wastes. However, the facility generates and treats wastewater from toxaphene but does not generate a sludge.

TABLE B-9

INDUSTRIAL FACILITY PROFILE

1. Waste stream: K025
   Distillation bottoms from the production of nitrobenzene by the nitration of benzene

2. Facility code: K025.1

3. Quantity generated: 16,500 pounds annually

4. Concentration of constituents of concern:

Meta-dinitrobenzene:	0.1-0.2%
2,4-dinitrotoluene:	<0.01%

Other constituents:

Benzene:	0.01%
Nitrobenzene:	96-98%
Aniline:	1-1.5%
Nitrotoluenes:	0.1%

5. Waste pH when mixed with equal weight of H_2O: 8-9

6. Flash point: 88°C

7. Radioactivity: N/A

8. Management procedures for case study waste:

   Basic Management Steps
   1. Wastes are stored in tanks prior to disposal.
   2. Wastes are incinerated.

TABLE B-10

INDUSTRIAL FACILITY PROFILE

1. Waste Stream: F009
   Spent stripping and cleaning bath solutions from electroplating operations where cyanides are used in the process.

2. Facility Code: F009.1 (a manufacturer of precision ordnance devices and components)

3. Quantity generated: Annually - 1400 gallons
   Disposed quarterly - 300-400 gallons

4. Concentrations of constituents of concern:
   Cyanide: .008 mg/l in treated wastewater; concentration in process water not known. The constituent concentrations vary with routine plant process changes.
   Other toxic constituents in batch treatment:
   Chromium: 0.35 mg/l after treatment
   Cadmium: <0.005 mg/l after treatment

5. Waste pH: 6.95 after treatment

6. Flash point: N/A

7. Radioactivity: N/A

8. Management procedures for case study waste:

   (1) The facility is presently operating a batch treatment system for plating wastes.
   (2) The process involves metal and cyanide reduction to EPA allowable limits in wastewater and wastewater discharge; dewatering of sludge through centrifugation; and disposal in commercial hazardous waste landfill.

9. Other waste undergoing same treatment, storage, and disposal procedures:

   Electrocleaner bath and cadmium plating baths are also disposed in batch treatment. Chromium in the solutions is reduced from the hexavalent to the trivalent state. The chromium reduction step involves the addition of polymers to enable metal hydroxides to settle out.

10. Waste segregation: All degreasing solvent wastes generated on site are segregated from metal- and cyanide-bearing wastes. The spent solvents are sent to a commercial treatment, recycling and disposal facility.

11. Case study waste management history: Several process/treatment changes were initiated in response to municipal standards following implementation of NPDES program. Subsequent RCRA regulations required no changes except administrative ones.

TABLE B-10

(continued)

12. Case study waste management plans: The facility is about to put a new treatment system in operation. This system will allow advanced treatment for chromium and cyanide destruction and acid reduction. The cyanide destruction process will include treatment with sodium hypochlorite and sulfuric acid in the primary stage and secondary treatment with a caustic solution.

13. Additional costs associated with RCRA requirements: All major changes and associated costs were incurred in response to NPDES requirements, not RCRA.

TABLE B-11

INDUSTRIAL FACILITY PROFILE

1. Waste stream: F009
   Spent stripping and cleaning bath solutions from electroplating where cyanides are used in the process

2. Facility code: F009.2 (a motor manufacturer)

3. Quantity generated: Annually: 3,420,000 gallons*
   Daily: 9,500 gallons*

4. Concentrations of constituents of concern:
   Cyanide (total): 0.060 mg/l
   Cyanide (amenable to chlorination): 0.058 mg/l

   Other constituents:

Floride:	0.28	mg/l
Cadmium:	<0.005	mg/l
Chromium:	2.66	mg/l
Copper:	0.14	mg/l
Iron:	0.15	mg/l
Lead:	<0.10	mg/l
Nickel:	0.81	mg/l
Silver:	0.02	mg/l
Tin:	0.82	mg/l
Zinc:	0.69	mg/l

5. Waste pH: 4.5; corrected to 7 - 8.5

6. Flash point: N/A

7. Radioactivity: N/A

8. Management procedures for case study waste:
   1. Effluent is directed to a 3-sectioned underground tank.
   2. The first section provides a settling basin.
   3. The second section provides a second settling basin.
   4. The third section provides a conduit to a publically owned treatment works.
   5. Potash is used to correct pH.

9. Other wastes undergoing same treatment, storage, and disposal procedures:
   F006: Wastewater treatment sludges from electroplating operations.
   F007: Spent plating bath solutions from electroplating operations.
   F008: Plating bath sludges from the bottom of plating baths from electroplating operations.

---

*Includes F006, F007 and F008 as well as F009.

TABLE B-11

(continued)

10. Waste segregation: All oils and solvents generated or used on site are segregated from electroplating wastes and sent to reclamation facility.

11. Case study waste management history: The only waste management change implemented recently has been a modification of the pH correction step. Administrative changes involve additional monitoring and recording and reporting of daily volume as well as sample analysis and monthly reporting.

12. Case study waste management plans: No major waste management changes are anticipated.

13. Additional costs associated by RCRA requirements: Cost of monthly sampling and reporting is about $200/month.

TABLE B-12

INDUSTRIAL FACILITY PROFILE

1. Waste stream: K074
   Wastewater treatment sludge from the production of titanium dioxide pigment using chromium bearing ores by the chloride process.

2. Facility code: K074.1 (a manufacturer of TiO_2 pigment and sulfuric acid)

3. Quantity generated: Annually: 3,600 tons
   Daily: 10 tons

4. Concentration of constituents of concern:
   Chromium, trivalent: 30 ppm
   hexavalent: < 1 ppm

   Other constituents:
   Lead: 20 ppm

5. Waste pH and (when mixed with an equal weight of H_2O) 2.5 - 4

6. Flash point: N/A

7. Radioactivity: N/A

8. Management procedures for case study waste:

   Basic Management Steps
   1. Sludges go to a weak acid holding pond.
   2. Sludges are settled out and supernatant is neutralized with limestone in the holding pond.
   3. Gypsum is produced in the holding pond. It is stockpiled and sold.
   4. Once or twice a year, sludge is dredged from the holding pond and titanium and coke are reclaimed from the chloride sludge and fed back into the manufacturing process.

9. Other wastes undergoing same treatment, storage, and disposal procedures:
   K075: Sulfide process sludges. The titanium in this sludge is not presently reclaimed as it is from the chloride sludge, however the feasibility of doing so is under consideration.

10. Case study waste management history: In 1975 with the implementation of NPDES requirements, the waste neutralization process was initiated.

11. Case study waste management plans: Facility managers expect to implement a system of reclaiming titanium and coke (30-40%) from the process stream before it goes to the holding pond. This change will occur within a few months.

TABLE B-12

(continued)

12. Additional costs associated with RCRA requirements: The only costs were those incurred in conjunction with EP toxicity testing and participation in the delisting process. These costs were not substantial.

TABLE B-13

INDUSTRIAL FACILITY PROFILE

1. Waste stream: K060
   Ammonia still lime sludge from coking

2. Facility code: K060.1 (a steel manufacturer)

3. Quantity generated annually: 400 tons

4. Concentration of constituents of concern:
   Cyanide: 55 mg/l

5. Waste pH (when mixed with equal weight of H_2O): 10.6

6. Flash point: N/A

7. Radioactivity: N/A

8. Waste variability relative to toxic constituent concentrations:
   ±20%

9. Management procedures for case study waste:
   Waste is mixed with metallic sludge from wastewater clarifiers.
   About 13 tons of metallic sludge is mixed with one ton of K060.
   Waste is landfilled.

10. Case study management history: The landfill location has recently been changed.

11. Additional costs associated with RCRA requirements: Additional waste transportation costs amounting to about $1,000 per month.

TABLE B-14

INDUSTRIAL FACILITY PROFILE

1. Waste stream: K060
   Ammonia still lime sludge from coking

2. Facility code: K060.2 (a steel manufacturer)

3. Quantity generated annually: 3,650 tons

4. Concentration of constituents of concern:
   Cyanide: 0.58 ppm
   Naphthalene: <3.8 ppm
   Phenolic compounds: 35.6 ppm
   Arsenic: 21 ppm

5. Waste pH: 10.2

6. Flash point: N/A

7. Radioactivity: N/A

8. Other wastes undergoing same treatment, storage and disposal procedures:
   K035: Wastewater treatment sludge from the production of creosote (50/50 milture K035 and K060).

APPENDIX C

SCORE SHEETS

The score sheets used in the development of Table 40 (Chapter 5) are presented in the subsequent pages of this appendix.

JRB

RATING FORM FOR WASTE DISPOSAL SITES

NAME OF SITE Degree of Hazard Landfill #1 ACTIVE: INACTIVE: INACTIVE AND ABANDONED (CIRCLE ONE)

LOCATION

OWNER/OPERATOR

COMMENTS:

PREPARED BY: ON 19

RATING FACTOR	SOURCE AND BASIS OF INFORMATION	FACTOR RATING (CIRCLE ONE)	MULTIPLIER	FACTOR SCORE	MAXIMUM POSSIBLE SCORE
RECEPTORS					
POPULATION WITHIN 1,000 FEET	5	0 [✓ 1] 2 3	12	12	36
DISTANCE TO NEAREST DRINKING WATER WELL	700 ft.	0 1 2 [✓ 3]	8	24	24
DISTANCE TO NEAREST OFF-SITE BUILDING	700 ft.	0 1 2 [✓ 3]	8	24	24
LAND USE/ZONING	Residential/agriculture	0 [✓ 1] 2 3	6	6	18
CRITICAL ENVIRONMENTS	Drainage ditch/wetlands	0 1 [✓ 2] 3	6	12	18
ADDITIONAL POINTS FOR OTHER RECEPTORS					50
			SUBTOTALS	78	120
			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		65

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 5.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

RATING FACTOR	SOURCE AND BASIS OF INFORMATION	FACTOR RATING (CIRCLE ONE)	MULTIPLIER	FACTOR SCORE	MAXIMUM POSSIBLE SCORE
PATHWAYS					
EVIDENCE OF CONTAMINATION	(after heavy rain)	0 1 2 [✓ 3]	2	6	6
LEVEL OF CONTAMINATION		0 1 [✓ 2] 3	7	14	21
TYPE OF CONTAMINATION	Water	0 1 2 [✓ 3]	5	15	15
DISTANCE TO NEAREST SURFACE WATER	1 mile	0 [✓ 1] 2 3	8	8	24
DEPTH TO GROUNDWATER	Approx. 9'	0 1 2 [✓ 3]	7	21	21
NET PRECIPITATION	Approx. 50"/yr	0 1 2 [✓ 3]	6	18	18
SOIL PERMEABILITY	Sandy soil	0 1 2 [✓ 3]	6	18	18
~~BEDROCK PERMEABILITY~~		~~0 1 2 3~~	~~4~~		~~12~~
DEPTH TO BEDROCK	> 700'	[✓ 0] 1 2 3	4	0	12
ADDITIONAL POINTS FOR OTHER PATHWAYS					25
			SUBTOTALS	100	135
			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		74

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 11.11 %.

JRB

RATING FORM FOR WASTE DISPOSAL SITES

NAME OF SITE Degree of Hazard Landfill #2 ACTIVE: INACTIVE: INACTIVE AND ABANDONED (CIRCLE ONE)

LOCATION

OWNER/OPERATOR

COMMENTS:

PREPARED BY: ON 19

RATING FACTOR	SOURCE AND BASIS OF INFORMATION	FACTOR RATING (CIRCLE ONE)	MULTI-PLIER	FACTOR SCORE	MAXIMUM POSSIBLE SCORE
RECEPTORS					
POPULATION WITHIN 1,000 FEET	6	0 [✓ 1] 2 3	12	12	36
DISTANCE TO NEAREST DRINKING WATER WELL	1/4 mile	0 1 2 [✓ 3]	8	24	24
DISTANCE TO NEAREST OFF-SITE BUILDING	1/4 mile	0 1 [✓ 2] 3	8	16	24
LAND USE/ZONING	Industrial	0 1 [✓ 2] 3	6	12	18
CRITICAL ENVIRONMENTS	River	0 1 [✓ 2] 3	6	12	18
ADDITIONAL POINTS FOR OTHER RECEPTORS					~~50~~

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 5.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

SUBTOTALS 76 120

SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100) 63

RATING FACTOR	SOURCE AND BASIS OF INFORMATION	FACTOR RATING (CIRCLE ONE)	MULTI-PLIER	FACTOR SCORE	MAXIMUM POSSIBLE SCORE
PATHWAYS					
EVIDENCE OF CONTAMINATION		[✓ 0] 1 2 3	2	0	6
LEVEL OF CONTAMINATION		[✓ 0] 1 2 3	7	0	21
TYPE OF CONTAMINATION		[✓ 0] 1 2 3	5	0	15
DISTANCE TO NEAREST SURFACE WATER	1/4 mile	0 1 [✓ 2] 3	8	16	24
DEPTH TO GROUNDWATER	5-40 ft.	0 1 2 3	7	21	21
NET PRECIPITATION	Approx. 64"	0 1 2 [✓ 3]	6	18	18
SOIL PERMEABILITY	10^{-4} - 10^{-5} cm/sec.	0 [✓ 1] 2 3	6	6	18
BEDROCK PERMEABILITY		~~0 1 2 3~~	~~4~~		~~12~~
DEPTH TO BEDROCK		~~0 1 2 3~~	~~4~~		~~12~~
ADDITIONAL POINTS FOR OTHER PATHWAYS					25

NUMBER OF MISSING AND ASSUMED VALUES = 2 OUT OF 9

PERCENTAGE OF MISSING AND ASSUMED VALUES = 22.22 %.

SUBTOTALS 61 123

SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100) 50

JRB

RATING FORM FOR WASTE DISPOSAL SITES

NAME OF SITE Degree of Hazard Landfill #3 ACTIVE: INACTIVE: INACTIVE AND ABANDONED (CIRCLE ONE)

LOCATION

OWNER/OPERATOR

COMMENTS:

PREPARED BY: ON 19

RATING FACTOR	SOURCE AND BASIS OF INFORMATION	FACTOR RATING (CIRCLE ONE)				MULTIPLIER	FACTOR SCORE	MAXIMUM POSSIBLE SCORE
				RECEPTORS				
POPULATION WITHIN 1,000 FEET	0	[✓ 0]	1	2	3	12	0	36
DISTANCE TO NEAREST DRINKING WATER WELL	> 1/2 mile	0	1	[✓ 2]	3	8	16	24
DISTANCE TO NEAREST OFF-SITE BUILDING	1/4 mile	0	1	[✓ 2]	3	8	16	24
LAND USE/ZONING	Comm./Ind./ Res.	0	1	[✓ 2]	3	6	12	18
CRITICAL ENVIRONMENTS	Creek, flood plain	0	1	[✓ 2]	3	6	12	18
ADDITIONAL POINTS FOR OTHER RECEPTORS								~~50~~
NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 5.						SUBTOTALS	56	120
PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		47
				PATHWAYS				
EVIDENCE OF CONTAMINATION		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
LEVEL OF CONTAMINATION		~~0~~	~~1~~	~~2~~	~~3~~	~~7~~		~~21~~
TYPE OF CONTAMINATION		~~0~~	~~1~~	~~2~~	~~3~~	~~5~~		~~15~~
DISTANCE TO NEAREST SURFACE WATER	<1 mile	0	1	[✓ 2]	3	8	16	24
DEPTH TO GROUNDWATER	11-30 ft	0	1	[✓ 2]	3	7	14	21
NET PRECIPITATION	approx. 45 in./yr.	0	1	2	[✓ 3]	6	18	18
SOIL PERMEABILITY	fine clay (loess)	[✓ 0]	1	2	3	6	0	18
BEDROCK PERMEABILITY		0	1	2	3	4		12
DEPTH TO BEDROCK	60 ft.	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER PATHWAYS								~~25~~
NUMBER OF MISSING AND ASSUMED VALUES = 4 OUT OF 9.						SUBTOTALS	52	93
PERCENTAGE OF MISSING AND ASSUMED VALUES = 44.44 %.						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		56

JRB

NAME OF SITE Landfill #1; Facility K071.1 Waste Stream

WASTE CHARACTERISTICS								
TOXICITY	High sax rating	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Metal	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		[✓ 0]	1	2	3	4	0	12
VOLATILITY	.0012 mm Hg	[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Bioaccumulative and mutagenic						6	20
						SUBTOTALS	46	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		33

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	5600 tons	0	1	2	[✓ 3]	7	21	21
TOTAL WASTE QUANTITY	140 acre feet	0	1	[✓ 2]	3	5	10	15
WASTE INCOMPATIBILITY	Wastes are segregated	0	[✓ 1]	2	3	5	5	15
USE OF LINERS	Bentonite	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	2	[✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0]	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS	None	0	1	2	[✓ 3]	2	6	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	51	102
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		50

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 3.2 %

TOTAL FACTOR SCORE 275

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 497

OVERALL SCORE 55
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE Landfill #2; Facility: K071.1 Waste Stream

WASTE CHARACTERISTICS					
TOXICITY	High sax rating	0 1 2 [✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0] 1 2 3	7	0	21
PERSISTENCE	Metal	0 1 2 [✓ 3]	5	15	15
IGNITABILITY		[✓ 0] 1 2 3	3	0	9
REACTIVITY		[✓ 0] 1 2 3	3	0	9
CORROSIVENESS		[✓ 0] 1 2 3	3	0	9
SOLUBILITY		[✓ 0] 1 2 3	4	0	12
VOLATILITY	.0012 mm Hg	[✓ 0] 1 2 3	4	0	12
PHYSICAL STATE	Sludge	0 [✓ 1] 2 3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Bioaccumulative and mutagenic			6	20
			SUBTOTALS	46	140
			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		33

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES					
SITE SECURITY	Locked Fence	[✓ 0] 1 2 3	7	0	21
HAZARDOUS WASTE QUANTITY	5600 tons	0 1 2 [✓ 3]	7	21	21
TOTAL WASTE QUANTITY	140 acre feet	0 1 [✓ 2] 3	5	10	15
WASTE INCOMPATIBILITY	Wastes are segregated	0 [✓ 1] 2 3	5	5	15
USE OF LINERS	Yes	[✓ 0] 1 2 3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	Yes	[✓ 0] 1 2 3	3	0	9
USE OF GAS COLLECTION SYSTEMS		~~0 1 2 3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS	Good	[✓ 0] 1 2 3	2	0	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES					~~30~~
			SUBTOTALS	36	96
			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		35

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 9.7 %

TOTAL FACTOR SCORE 219

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 479

OVERALL SCORE 46
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE Landfill #3; Facility: K071.1 Waste Stream

WASTE CHARACTERISTICS								
TOXICITY	High sax rating	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Metal	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		[✓ 0]	1	2	3	4	0	12
VOLATILITY	.0012 mm Hg	[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Bioaccumulative and mutagenic						6	20
						SUBTOTALS	46	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		33

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Fence, guard	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	5600 tons	0	1	2	3	7	21	21
TOTAL WASTE QUANTITY	140 acre feet	0	1	2	3	5	10	15
WASTE INCOMPATIBILITY	Wastes are segregated	0	1	2	3	5	5	15
USE OF LINERS	None	0	1	2	[✓ 3]	3	9	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	[✓ 2]	3	3	6	9
USE OF GAS COLLECTION SYSTEMS		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS		0	[✓ 1]	2	3	2	2	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	53	96
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		55

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

NUMBER OF MISSING AND ASSUMED VALUES = 4 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.9 %

TOTAL FACTOR SCORE 207

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 461

OVERALL SCORE 45
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE Landfill #1; Facility: K071.2 Waste Stream

WASTE CHARACTERISTICS								
TOXICITY	High	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Metal	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		[✓ 0]	1	2	3	4	0	12
VOLATILITY	.0012 mm Hg	[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Bioaccumulative and mutagenic						6	20
						SUBTOTALS	46	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		33

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	11,000 tons	0	1	2	[✓ 3]	7	21	21
TOTAL WASTE QUANTITY	8.15 acre feet	[✓ 0]	1	2	3	5	0	15
WASTE INCOMPATIBILITY		0	[✓ 1]	2	3	5	5	15
USE OF LINERS	Bentonite	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	2	[✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0]	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS	None	0	1	2	[✓ 3]	2	6	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	41	102
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		40

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 3.2 %

TOTAL FACTOR SCORE 265

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 497

OVERALL SCORE 53
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE Degree of Hazard Landfill #2 : Facility : K071.2 Waste Stream

WASTE CHARACTERISTICS								
TOXICITY	High	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Metal	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		[✓ 0]	1	2	3	4	0	12
VOLATILITY	0.0012 mm Hg	[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Bioaccumulative & Mutagenic						6	20
						SUBTOTALS	46	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		33

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked Fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	11,000 tons	0	1	2	[✓ 3]	7	21	21
TOTAL WASTE QUANTITY	8.15 acre-ft.	[✓ 0]	1	2	3	5	0	15
WASTE INCOMPATIBILITY		0	[✓ 1]	2	3	5	5	15
USE OF LINERS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF GAS COLLECTION SYSTEMS		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS	Good	[✓ 0]	1	2	3	2	0	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~39~~
						SUBTOTALS	26	96
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		27

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 9.7 %

TOTAL FACTOR SCORE 209

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 479

OVERALL SCORE 44
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE Landfill #3; Facility: K071.2 Waste Stream

WASTE CHARACTERISTICS								
TOXICITY	High	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Metal	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		[✓ 0]	1	2	3	4	0	12
VOLATILITY	.0012 mm Hg	[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Bioaccumulative and mutagenic						6	20
						SUBTOTALS	46	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		33

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Fence, guard	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	11,000 tons	0	1	2	[✓ 3]	7	21	21
TOTAL WASTE QUANTITY	8.15 acre feet	[✓ 0]	1	2	3	5	0	15
WASTE INCOMPATIBILITY		0	[✓ 1]	2	3	5	5	15
USE OF LINERS	None	0	1	2	[✓ 3]	3	9	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	[✓ 2]	3	3	6	9
USE OF GAS COLLECTION SYSTEMS		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS		0	[✓ 1]	2	3	2	2	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	43	96
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		45

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

NUMBER OF MISSING AND ASSUMED VALUES = 4 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.9 %

TOTAL FACTOR SCORE 197

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 461

OVERALL SCORE 43
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE Landfill #1; Facility: K071.3 Waste Stream

WASTE CHARACTERISTICS								
TOXICITY	High sax rating	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Metal	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		[✓ 0]	1	2	3	4	0	12
VOLATILITY	.0012 mm Hg	[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Bioaccumulative and mutagenic						6	20
						SUBTOTALS	46	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		33

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	2260 Tons	0	1	2	3	7	21	21
TOTAL WASTE QUANTITY	2 acre feet	0	1	2	3	5	0	15
WASTE INCOMPATIBILITY	Assumed	0	1	2	3	5	10	15
USE OF LINERS	Bentonite	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	2	[✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0]	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS	None	0	1	2	[✓ 3]	2	6	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~33~~
						SUBTOTALS	46	102
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		45

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 3.2 %

TOTAL FACTOR SCORE 270

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 497

OVERALL SCORE 54
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE Landfill #2; Facility K071.3 Waste Stream

WASTE CHARACTERISTICS								
TOXICITY	High sax rating	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Metal	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		[✓ 0]	1	2	3	4	0	12
VOLATILITY	.0012 mm Hg	[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Bioaccumulative and mutagenic						6	20
						SUBTOTALS	46	140

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100) 33

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked Fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	2260 tons	0	1	2	[✓ 3]	7	21	21
TOTAL WASTE QUANTITY	2 acre feet	[✓ 0]	1	2	3	5	0	15
WASTE INCOMPATIBILITY	Assumed	0	1	[✓ 2]	3	5	10	15
USE OF LINERS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF GAS COLLECTION SYSTEMS		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS	Good	[✓ 0]	1	2	3	2	0	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	31	96

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100) 32

NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 9.7 %

TOTAL FACTOR SCORE 214

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 479

OVERALL SCORE 45
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE Landfill #3; Facility K071.3 Waste Stream

WASTE CHARACTERISTICS								
TOXICITY	High sax rating	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Metal	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		[✓ 0]	1	2	3	4	0	12
VOLATILITY	.0012 mm Hg	[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Bioaccumulative and mutagenic						6	20
						SUBTOTALS	46	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		33

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Fence, guard	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	2260 tons	0	1	2	[✓ 3]	7	21	21
TOTAL WASTE QUANTITY	2 acre feet	[✓ 0]	1	2	3	5	0	15
WASTE INCOMPATIBILITY	Assumed	0	1	[✓ 2]	3	5	10	15
USE OF LINERS	None	0	1	2	[✓ 3]	3	9	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	[✓ 2]	3	3	6	9
USE OF GAS COLLECTION SYSTEMS		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS		0	[✓ 1]	2	3	2	0	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	46	96
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		48

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

NUMBER OF MISSING AND ASSUMED VALUES = 4 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.9 %

TOTAL FACTOR SCORE 200

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 461

OVERALL SCORE 43

(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE LANDFILL #1; FACILITY: K013.1 WASTE STREAM

WASTE CHARACTERISTICS

TOXICITY	HCN & Acrylonitrile	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE		0	1	[✓ 2]	3	5	10	15
IGNITABILITY	NFPA 3&4	0	1	2	[✓ 3]	3	9	9
REACTIVITY	NFPA 2	0	1	[✓ 2]	3	3	6	9
CORROSIVENESS	pH 5.5-6	0	[✓ 1]	2	3	3	3	9
SOLUBILITY		0	1	[✓ 2]	3	4	8	12
VOLATILITY		0	1	2	[✓ 3]	4	12	12
PHYSICAL STATE		0	1	[✓ 2]	3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Bioaccumulative, teratogenic						6	20
						SUBTOTALS	83	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		59

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES

SITE SECURITY	Locked fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY		0	1	2	[✓ 3]	7	21	21
TOTAL WASTE QUANTITY		0	1	2	[✓ 3]	5	15	15
WASTE INCOMPATIBILITY		[✓ 0]	1	2	3	5	0	15
USE OF LINERS	Bentonite	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	2	[✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0]	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS	None	0	1	2	[✓ 3]	2	6	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	51	102
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		50

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 3.2 %

TOTAL FACTOR SCORE 312

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 497

OVERALL SCORE 63
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE LANDFILL #2; FACILITY: K013.1 WASTE STREAM

WASTE CHARACTERISTICS

TOXICITY	HCN & Acrylonitrile	0 1 2 [✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0] 1 2 3	7	0	21
PERSISTENCE	NFPA 3&4	0 1 [✓ 2] 3	5	10	15
IGNITABILITY	NFPA 2	0 1 2 [✓ 3]	3	9	9
REACTIVITY	pH 5.5-6	0 1 [✓ 2] 3	3	6	9
CORROSIVENESS		0 [✓ 1] 2 3	3	3	9
SOLUBILITY		0 1 [✓ 2] 3	4	8	12
VOLATILITY		0 1 2 [✓ 3]	4	12	12
PHYSICAL STATE		0 1 [✓ 2] 3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Bioaccumulative, teratogenic			6	20
			SUBTOTALS	83	140
			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		59

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES

SITE SECURITY	Locked Fence	[✓ 0] 1 2 3	7	0	21
HAZARDOUS WASTE QUANTITY		0 1 2 [✓ 3]	7	21	21
TOTAL WASTE QUANTITY		0 1 2 [✓ 3]	5	15	15
WASTE INCOMPATIBILITY		[✓ 0] 1 2 3	5	0	15
USE OF LINERS	Yes	[✓ 0] 1 2 3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	Yes	[✓ 0] 1 2 3	3	0	9
USE OF GAS COLLECTION SYSTEMS		~~0 1 2 3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS	Good	[✓ 0] 1 2 3	2	0	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES					~~39~~
			SUBTOTALS	36	96
			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		38

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 9.7 %

TOTAL FACTOR SCORE 256

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 479

OVERALL SCORE 53
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

JRB

NAME OF SITE LANDFILL #3: FACILITY K013.1 WASTE

WASTE CHARACTERISTICS					
TOXICITY	HCN and acrylonitrile	0 1 2 [✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0] 1 2 3	7	0	21
PERSISTENCE		0 1 [✓ 2] 3	5	10	15
IGNITABILITY	NFPA 3, 4	0 1 2 [✓ 3]	3	9	9
REACTIVITY	NFPA 2	0 1 [✓ 2] 3	3	6	9
CORROSIVENESS	pH 5.5-6	0 [✓ 1] 2 3	3	3	9
SOLUBILITY		0 1 [✓ 2] 3	4	8	12
VOLATILITY		0 1 2 [✓ 3]	4	12	12
PHYSICAL STATE		0 1 [✓ 2] 3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Bioaccumulative, teratogenic			6	20
			SUBTOTALS	83	140
			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		59

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES					
SITE SECURITY	Fence, guard	[✓ 0] 1 2 3	7	0	21
HAZARDOUS WASTE QUANTITY		0 1 2 [✓ 3]	7	21	21
TOTAL WASTE QUANTITY		0 1 2 [✓ 3]	5	15	15
WASTE INCOMPATIBILITY		[✓ 0] 1 2 3	5	0	15
USE OF LINERS	None	0 1 2 [✓ 3]	3	9	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0 1 [✓ 2] 3	3	6	9
USE OF GAS COLLECTION SYSTEMS		~~0 1 2 3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS		0 [✓ 1] 2 3	2	2	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES					~~30~~
			SUBTOTALS	53	96
			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		55

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

NUMBER OF MISSING AND ASSUMED VALUES = 4 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.9 %

TOTAL FACTOR SCORE 244

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 461

OVERALL SCORE 53
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

JRB

NAME OF SITE Landfill #1 K013.2

WASTE CHARACTERISTICS					
TOXICITY	Hydrocyanic acid	0 1 2 [✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0] 1 2 3	7	0	21
PERSISTENCE		[✓ 0] 1 2 3	5	0	15
IGNITABILITY		[✓ 0] 1 2 3	3	0	9
REACTIVITY		[✓ 0] 1 2 3	3	0	9
CORROSIVENESS		[✓ 0] 1 2 3	3	0	9
SOLUBILITY		0 1 2 [✓ 3]	4	12	12
VOLATILITY		0 [✓ 1] 2 3	4	4	12
PHYSICAL STATE		0 1 [✓ 2] 3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Carcinogenic			4	20
			SUBTOTALS	49	120
			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		41

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES					
SITE SECURITY	Locked fence	[✓ 0] 1 2 3	7	0	21
HAZARDOUS WASTE QUANTITY	360,000 Tons/year	0 1 2 [✓ 3]	7	21	21
TOTAL WASTE QUANTITY		0 1 2 [✓ 3]	5	15	15
WASTE INCOMPATIBILITY		[✓ 0] 1 2 3	5	0	15
USE OF LINERS	Bentonite	[✓ 0] 1 2 3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0 1 2 [✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0] 1 2 3	2	0	6
USE AND CONDITION OF CONTAINERS	None	0 1 2 [✓ 3]	2	6	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES					~~30~~
			SUBTOTALS	51	102
			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		50

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 3.2 %

TOTAL FACTOR SCORE 278

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 477

OVERALL SCORE 58
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

JRB

NAME OF SITE Landfill #2 K013.2

WASTE CHARACTERISTICS

TOXICITY	Hydrocyanic acid	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE		[✓ 0]	1	2	3	5	0	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		0	1	2	[✓ 3]	4	12	12
VOLATILITY		0	[✓ 1]	2	3	4	4	12
PHYSICAL STATE		0	1	[✓ 2]	3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Carcinogenic						4	20
						SUBTOTALS	49	120
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		41

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES

SITE SECURITY	Locked fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	360,000 Tons/year	0	1	2	[✓ 3]	7	21	21
TOTAL WASTE QUANTITY		0	1	2	[✓ 3]	5	15	15
WASTE INCOMPATIBILITY		[✓ 0]	1	2	3	5	0	15
USE OF LINERS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0]	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS	Good	[✓ 0]	1	2	3	2	0	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	36	102
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		35

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

NUMBER OF MISSING AND ASSUMED VALUES = 2 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 6.4 %

TOTAL FACTOR SCORE 222

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 465

OVERALL SCORE 48
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE Landfill #3 K013.2

WASTE CHARACTERISTICS

TOXICITY	Hydrocyanic acid	0 1 2 [✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0] 1 2 3	7	0	21
PERSISTENCE		[✓ 0] 1 2 3	5	0	15
IGNITABILITY		[✓ 0] 1 2 3	3	0	9
REACTIVITY		[✓ 0] 1 2 3	3	0	9
CORROSIVENESS		[✓ 0] 1 2 3	3	0	9
SOLUBILITY		0 1 2 [✓ 3]	4	12	12
VOLATILITY		0 [✓ 1] 2 3	4	4	12
PHYSICAL STATE		0 1 [✓ 2] 3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Carcinogenic			4	20
			SUBTOTALS	49	120
			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		41

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES

SITE SECURITY	Fence, guard	[✓ 0] 1 2 3	7	0	21
HAZARDOUS WASTE QUANTITY	360,000 Tons/year	0 1 2 [✓ 3]	7	21	21
TOTAL WASTE QUANTITY		0 1 2 [✓ 3]	5	15	15
WASTE INCOMPATIBILITY		[✓ 0] 1 2 3	5	0	15
USE OF LINERS	None	0 1 2 [✓ 3]	3	9	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0 1 [✓ 2] 3	3	6	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0] 1 2 3	2	0	6
USE AND CONDITION OF CONTAINERS		0 [✓ 1] 2 3	2	2	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES					~~30~~
			SUBTOTALS	53	102
			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		52

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 9.7 %

TOTAL FACTOR SCORE 210

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 447

OVERALL SCORE 47
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE LANDFILL #1; FACILITY: K073.1 WASTE

WASTE CHARACTERISTICS								
TOXICITY	8 Toxic Organic Constits.	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE		0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS	12 at landfill pH 1-2 at process area;	0	1	2	[✓ 3]	3	9	9
SOLUBILITY		0	[✓ 1]	2	3	4	4	12
VOLATILITY		0	1	2	[✓ 3]	4	12	12
PHYSICAL STATE		0	1	[✓ 2]	3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS							6	20
						SUBTOTALS	75	140

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

SUBSCORE 54
(FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	30 pounds	[✓ 0]	1	2	3	7	0	21
TOTAL WASTE QUANTITY	165 acre feet	0	1	[✓ 2]	3	5	10	15
WASTE INCOMPATIBILITY		[✓ 0]	1	2	3	5	0	15
USE OF LINERS	bentonite	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	2	[✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0]	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS	None	0	1	2	[✓ 3]	2	6	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	25	102

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

SUBSCORE 25
(FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 3.2 %

TOTAL FACTOR SCORE 278

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 497

OVERALL SCORE 56
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

JRE

NAME OF SITE LANDFILL #2; FACILITY: K073.1 WASTE

WASTE CHARACTERISTICS								
TOXICITY	8 Toxic Organic Constituents	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE		0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS	pH 1 - 2 at process area; 12 at landfill	0	1	2	[✓ 3]	3	9	9
SOLUBILITY		0	[✓ 1]	2	3	4	4	12
VOLATILITY		0	1	2	[✓ 3]	4	12	12
PHYSICAL STATE		0	1	2	3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS							6	20
						SUBTOTALS	75	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		54

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	30 pounds	[✓ 0]	1	2	3	7	0	21
TOTAL WASTE QUANTITY	165 acre feet	0	1	[✓ 2]	3	5	10	15
WASTE INCOMPATIBILITY		[✓ 0]	1	2	3	5	0	15
USE OF LINERS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF GAS COLLECTION SYSTEMS		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS	Good	[✓ 0]	1	2	3	2	0	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	10	96
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		10

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 9.7 %

TOTAL FACTOR SCORE 222

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 479

OVERALL SCORE 46
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE LANDFILL #3; FACILITY K073.1 WASTE

WASTE CHARACTERISTICS

TOXICITY	8 toxic organic constituents	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE		0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS	pH 1-2 at process area; 12 at landfill	0	1	2	[✓ 3]	3	9	9
SOLUBILITY		0	[✓ 1]	2	3	4	4	12
VOLATILITY		0	1	2	[✓ 3]	4	12	12
PHYSICAL STATE		0	1	[✓ 2]	3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS							~~6~~	~~20~~
						SUBTOTALS	75	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		54

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES

SITE SECURITY	Fence, guard	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	30 pounds	[✓ 0]	1	2	3	7	0	21
TOTAL WASTE QUANTITY	165 acre feet	0	1	[✓ 2]	3	5	10	15
WASTE INCOMPATIBILITY		[✓ 0]	1	2	3	5	0	15
USE OF LINERS	None	0	1	2	[✓ 3]	3	9	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	[✓ 2]	3	3	6	9
USE OF GAS COLLECTION SYSTEMS		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS		0	[✓ 1]	2	3	2	2	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	27	96
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		28

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

NUMBER OF MISSING AND ASSUMED VALUES = 4 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.9 %

TOTAL FACTOR SCORE 210

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 461

OVERALL SCORE 46

(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE LANDFILL #1; FACILITY K041.2 WASTE STREAM

WASTE CHARACTERISTICS								
TOXICITY		0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Polycyclic	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY	Soluble	0	1	[✓ 2]	3	4	8	12
VOLATILITY	0.2 - 0.4 mm Hg	[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Liquid	0	1	[✓ 2]	3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Carcinogenic and Bioaccumulative						6	20

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

SUBTOTALS 58 140

SUBSCORE 41
(FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	86,500 tons	0	1	2	[✓ 3]	7	21	21
TOTAL WASTE QUANTITY	63.6 acre-ft	0	[✓ 1]	2	3	5	5	15
WASTE INCOMPATIBILITY	None	[✓ 0]	1	2	3	5	0	15
USE OF LINERS	Bentonite	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	2	[✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0]	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS	None	0	1	2	[✓ 3]	2	6	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

SUBTOTALS 41 102

SUBSCORE 40
(FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 3.2 %

TOTAL FACTOR SCORE 277

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 497

OVERALL SCORE 56
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

WASTE CHARACTERISTICS

TOXICITY		0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Polycyclic	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY	Soluble	0	1	[✓ 2]	3	4	8	12
VOLATILITY	0.2 - 0.4 mm Hg	[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Liquid	0	1	[✓ 2]	3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Carcihogenic & Bioaccumulative						6	20
						SUBTOTALS	58	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		41

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES

SITE SECURITY	Locked Fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	86,500 tons	0	1	2	[✓ 3]	7	21	21
TOTAL WASTE QUANTITY	63.6 acre feet	0	[✓ 1]	2	3	5	5	15
WASTE INCOMPATIBILITY	None	[✓ 0]	1	2	3	5	0	15
USE OF LINERS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF GAS COLLECTION SYSTEMS		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS	Good	[✓ 0]	1	2	3	2	0	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	26	96
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		27

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 9.7 %

TOTAL FACTOR SCORE 221

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 479

OVERALL SCORE 46
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

JRB

NAME OF SITE Degree of Hazard Landfill #3: FACILITY K041.2 WASTE

WASTE CHARACTERISTICS								
TOXICITY		0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Polycyclic	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY	Soluble	0	1	[✓ 2]	3	4	8	12
VOLATILITY	0.2-0.4 mm Hg	[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Liquid	0	1	[✓ 2]	3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Carcinogenic and bioaccumulative						6	20
						SUBTOTALS	58	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		41

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Fence, guard	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	86,500 Tons	0	1	2	[✓ 3]	7	21	21
TOTAL WASTE QUANTITY	63.6 acre-ft.	0	[✓ 1]	2	3	5	5	15
WASTE INCOMPATIBILITY	None	[✓ 0]	1	2	3	5	0	15
USE OF LINERS	None	0	1	2	[✓ 3]	3	9	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	[✓ 2]	3	3	6	9
USE OF GAS COLLECTION SYSTEMS		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS		0	[✓ 1]	2	3	2	2	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	43	102
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		42

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

NUMBER OF MISSING AND ASSUMED VALUES = 4 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.9 %

TOTAL FACTOR SCORE 209

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 467

OVERALL SCORE 45
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE LANDFILL #1; FACILITY: F009.1 Waste

WASTE CHARACTERISTICS								
TOXICITY	NaCn, KCn	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE		[✓ 0]	1	2	3	5	0	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		0	1	[✓ 2]	3	4	8	12
VOLATILITY		0	[✓ 1]	2	3	4	4	12
PHYSICAL STATE		0	1	[✓ 2]	3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Mutagenic						4	20
						SUBTOTALS	45	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		32

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	140 gallons	[✓ 0]	1	2	3	7	0	21
TOTAL WASTE QUANTITY		[✓ 0]	1	2	3	5	0	15
WASTE INCOMPATIBILITY		0	[✓ 1]	2	3	5	5	15
USE OF LINERS	Bentonite	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	2	[✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0]	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS	None	0	1	2	[✓ 3]	2	6	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	20	102
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		20

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 3.2 %

TOTAL FACTOR SCORE 243

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 497

OVERALL SCORE 49
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE LANDFILL #2; FACILITY: F009.1 Waste

WASTE CHARACTERISTICS								
TOXICITY	NaCn, KCn	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE		[✓ 0]	1	2	3	5	0	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		0	1	[✓ 2]	3	4	8	12
VOLATILITY		0	[✓ 1]	2	3	4	4	12
PHYSICAL STATE		0	1	[✓ 2]	3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Mutagenic						4	20
						SUBTOTALS	45	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		32

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked Fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	1400 gallons	[✓ 0]	1	2	3	7	0	21
TOTAL WASTE QUANTITY		[✓ 0]	1	2	3	5	0	15
WASTE INCOMPATIBILITY		0	[✓ 1]	2	3	5	5	15
USE OF LINERS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF GAS COLLECTION SYSTEMS		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS	Good	[✓ 0]	1	2	3	2	0	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	5	96
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		52

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 9.7 %

TOTAL FACTOR SCORE 187

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 479

OVERALL SCORE 39
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

JRB

NAME OF SITE LANDFILL #3; FACILITY: F009.1 WASTE

WASTE CHARACTERISTICS								
TOXICITY	NaCn; KCn	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE		[✓ 0]	1	2	3	5	0	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		0	1	[✓ 2]	3	4	8	12
VOLATILITY		0	[✓ 1]	2	3	4	4	12
PHYSICAL STATE		0	1	[✓ 2]	3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Mutagenic						4	20
						SUBTOTALS	45	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		32

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Fence, guard	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	1400 gallons	[✓ 0]	1	2	3	7	0	21
TOTAL WASTE QUANTITY		[✓ 0]	1	2	3	5	0	15
WASTE INCOMPATIBILITY		0	[✓ 1]	2	3	5	5	15
USE OF LINERS	None	0	1	2	[✓ 3]	3	9	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	2	[✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS		0	[✓ 1]	2	3	2	2	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	25	96
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		26

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

NUMBER OF MISSING AND ASSUMED VALUES = 4 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.9 %

TOTAL FACTOR SCORE 178

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 461

OVERALL SCORE 39
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

JRB

NAME OF SITE LANDFILL #1; FACILITY: F009.2 WASTE

WASTE CHARACTERISTICS								
TOXICITY	Na Cn; KCn	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE		[✓ 0]	1	2	3	5	0	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		0	1	[✓ 2]	3	4	8	12
VOLATILITY		0	[✓ 1]	2	3	4	4	12
PHYSICAL STATE		0	1	[✓ 2]	3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Mutagenic						4	20
						SUBTOTALS	45	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		32

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked Fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	3,420,000	0	1	2	[✓ 3]	7	21	21
TOTAL WASTE QUANTITY		0	[✓ 1]	2	3	5	5	15
WASTE INCOMPATIBILITY		0	[✓ 1]	2	3	5	5	15
USE OF LINERS	Bentonite	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	2	[✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0]	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS	None	0	1	2	[✓ 3]	2	6	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	46	102
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		45

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 3.2 %

TOTAL FACTOR SCORE 269

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 497

OVERALL SCORE 54

(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE LANDFILL #2; FACILITY: F009.2

WASTE CHARACTERISTICS								
TOXICITY	Na Cn; KCn	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE		[✓ 0]	1	2	3	5	0	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		0	1	[✓ 2]	3	4	8	12
VOLATILITY		0	[✓ 1]	2	3	4	4	12
PHYSICAL STATE		0	1	[✓ 2]	3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Mutagenic						4	20
						SUBTOTALS	45	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		32

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked Fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	3,420,000	0	1	2	[✓ 3]	7	21	21
TOTAL WASTE QUANTITY		0	[✓ 1]	2	3	5	5	15
WASTE INCOMPATIBILITY		0	[✓ 1]	2	3	5	5	15
USE OF LINERS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF GAS COLLECTION SYSTEMS		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS	Good	[✓ 0]	1	2	3	2	0	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	31	96
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		32

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 9.7 %

TOTAL FACTOR SCORE 213

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 479

OVERALL SCORE 44
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE LANDFILL #3; FACILITY: F009.2

WASTE CHARACTERISTICS

TOXICITY	Na Cn, KCn	0 1 2 [✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0] 1 2 3	7	0	21
PERSISTENCE		[✓ 0] 1 2 3	5	0	15
IGNITABILITY		[✓ 0] 1 2 3	3	0	9
REACTIVITY		[✓ 0] 1 2 3	3	0	9
CORROSIVENESS		[✓ 0] 1 2 3	3	0	9
SOLUBILITY		0 1 [✓ 2] 3	4	8	12
VOLATILITY		0 [✓ 1] 2 3	4	4	12
PHYSICAL STATE		0 1 [✓ 2] 3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Mutagenic			4	20
			SUBTOTALS	45	140
			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		32

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES

SITE SECURITY	Fence, guard	[✓ 0] 1 2 3	7	0	21
HAZARDOUS WASTE QUANTITY	3,420,000	0 1 2 [✓ 3]	7	21	21
TOTAL WASTE QUANTITY		0 [✓ 1] 2 3	5	5	15
WASTE INCOMPATIBILITY		0 [✓ 1] 2 3	5	5	15
USE OF LINERS	None	0 1 2 [✓ 3]	3	9	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0 1 [✓ 2] 3	3	6	9
USE OF GAS COLLECTION SYSTEMS		~~0 1 2 3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS		0 [✓ 1] 2 3	2	2	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES					~~30~~
			SUBTOTALS	48	96
			SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		50

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.5 %.

NUMBER OF MISSING AND ASSUMED VALUES = 4 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.9 %

TOTAL FACTOR SCORE 201

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 461

OVERALL SCORE 44
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE Landfill #1 K060.1

WASTE CHARACTERISTICS								
TOXICITY	Cyanide	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE		0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		0	1	[✓ 2]	3	3	6	9
SOLUBILITY		~~0~~	~~1~~	~~2~~	~~3~~	~~4~~		~~12~~
VOLATILITY		[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS							0	20
						SUBTOTALS	46	128
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		36

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 11.11 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	400 Tons/year	0	[✓ 1]	2	3	7	7	21
TOTAL WASTE QUANTITY		0	1	[✓ 2]	3	5	10	15
WASTE INCOMPATIBILITY		[✓ 0]	1	2	3	5	0	15
USE OF LINERS	Bentonite	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	2	[✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0]	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS	None	0	1	2	[✓ 3]	2	6	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	32	102
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		31

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

NUMBER OF MISSING AND ASSUMED VALUES = 2 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 6.45 %

TOTAL FACTOR SCORE 256

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 485

OVERALL SCORE 53
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE Landfill #2 K060.1

WASTE CHARACTERISTICS								
TOXICITY	Cyanide	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE		0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		0	1	[✓ 2]	3	3	6	9
SOLUBILITY		~~0~~	~~1~~	~~2~~	~~3~~	~~4~~		~~12~~
VOLATILITY		[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS							0	20
						SUBTOTALS	46	128
						SUBTOTALS		

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 11.11 %.

SUBTOTALS 46 128

SUBSCORE 36
(FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	400 tons/year	0	[✓ 1]	2	3	7	7	21
TOTAL WASTE QUANTITY		0	1	[✓ 2]	3	5	10	15
WASTE INCOMPATIBILITY		[✓ 0]	1	2	3	5	0	15
USE OF LINERS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0]	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS	Good	[✓ 0]	1	2	3	2	0	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

SUBTOTALS 17 102

SUBSCORE 17
(FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 9.68 %

TOTAL FACTOR SCORE 200

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 473

OVERALL SCORE 42
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

JRB

NAME OF SITE Landfill #3 K060.1

WASTE CHARACTERISTICS

TOXICITY	Cyanide	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE		0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		0	1	[✓ 2]	3	3	6	9
SOLUBILITY		~~0~~	~~1~~	~~2~~	~~3~~	~~4~~		~~12~~
VOLATILITY		[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS							0	20
						SUBTOTALS	46	128
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		36

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 11.11 %.

WASTE MANAGEMENT PRACTICES

SITE SECURITY	Fence, guard	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	400 Tons/year	0	[✓ 1]	2	3	7	7	21
TOTAL WASTE QUANTITY		0	1	[✓ 2]	3	5	10	15
WASTE INCOMPATIBILITY		[✓ 0]	1	2	3	5	0	15
USE OF LINERS	None	0	1	2	[✓ 3]	3	9	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	2	[✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0]	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS		0	[✓ 1]	2	3	2	2	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	37	102
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		36

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

NUMBER OF MISSING AND ASSUMED VALUES = 4 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 12.9 %

TOTAL FACTOR SCORE 191

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 455

OVERALL SCORE 42
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE Landfill #1 K060.2

	WASTE CHARACTERISTICS							
TOXICITY	Phenol	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Cyanide	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		0	1	[✓ 2]	3	3	6	9
SOLUBILITY		0	1	2	[✓ 3]	4	12	12
VOLATILITY		[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Phenol & arsenic/carcinogenic						8	20
						SUBTOTALS	66	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		47

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

	WASTE MANAGEMENT PRACTICES							
SITE SECURITY	Locked fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	3650 Tons/year	0	1	2	[✓ 3]	7	21	21
TOTAL WASTE QUANTITY		0	1	2	[✓ 3]	5	15	15
WASTE INCOMPATIBILITY		[✓ 0]	1	2	3	5	0	15
USE OF LINERS	Bentonite	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	2	[✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0]	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS	None	0	1	2	[✓ 3]	2	6	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	51	102
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		50

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 3.2 %

TOTAL FACTOR SCORE 295

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 497

OVERALL SCORE 59

(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

JRB

NAME OF SITE Landfill #2 K060.2

WASTE CHARACTERISTICS								
TOXICITY	Phenol	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Cyanide	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		0	1	[✓ 2]	3	3	6	9
SOLUBILITY		0	1	2	[✓ 3]	4	12	12
VOLATILITY		[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Phenol and arsenic/carcinogenic						8	20
						SUBTOTALS	66	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		47

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	3650 tons/year	0	1	2	[✓ 3]	7	21	21
TOTAL WASTE QUANTITY		0	1	2	[✓ 3]	5	15	15
WASTE INCOMPATIBILITY		[✓ 0]	1	2	3	5	0	15
USE OF LINERS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0]	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS	Good	[✓ 0]	1	2	3	2	0	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	36	102
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		35

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

NUMBER OF MISSING AND ASSUMED VALUES = 2 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 6.45 %

TOTAL FACTOR SCORE 239

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 485

OVERALL SCORE 49
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

JRB

NAME OF SITE Landfill #3 K060.2

WASTE CHARACTERISTICS								
TOXICITY	Phenol	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE	Cyanide	0	1	2	[✓ 3]	5	15	15
IGNITABILITY		[✓ 0]	1	2	3	3	0	9
REACTIVITY		[✓ 0]	1	2	3	3	0	9
CORROSIVENESS		0	1	[✓ 2]	3	3	6	9
SOLUBILITY		0	1	2	[✓ 3]	4	12	12
VOLATILITY		[✓ 0]	1	2	3	4	0	12
PHYSICAL STATE	Sludge	0	[✓ 1]	2	3	4	4	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Phenol & arsenic/carcinogenic						8	20
						SUBTOTALS	66	140
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		47

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Fence, guard	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	3650 tons/year	0	1	2	[✓ 3]	7	21	21
TOTAL WASTE QUANTITY		0	1	2	[✓ 3]	5	15	15
WASTE INCOMPATIBILITY		[✓ 0]	1	2	3	5	0	15
USE OF LINERS	None	0	1	2	[✓ 3]	3	9	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	2	[✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0]	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS		0	[✓ 1]	2	3	2	2	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	56	102
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		55

NUMBER OF MISSING AND ASSUMED VALUES = 0 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 0 %.

NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 9.7 %

TOTAL FACTOR SCORE 230

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 467

OVERALL SCORE 49
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

JRE

NAME OF SITE LANDFILL #1; FACILITY: K025.1 WASTE

WASTE CHARACTERISTICS								
TOXICITY	Meta-dinitrobenzene, 2,4-dinitrotoluene	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE		0	1	[✓ 2]	3	5	10	15
IGNITABILITY		0	1	[✓ 2]	3	3	6	9
REACTIVITY		0	1	2	[✓ 3]	3	9	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		[✓ 0]	1	2	3	4	0	12
~~VOLATILITY~~		~~0~~	~~1~~	~~2~~	~~3~~	~~4~~		~~12~~
PHYSICAL STATE		0	1	[✓ 2]	3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Carcinogenic						4	20
						SUBTOTALS	58	128
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		45

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 11.1 %.

WASTE MANAGEMENT PRACTICES								
SITE SECURITY	Locked fence	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY		[✓ 0]	1	2	3	7	0	21
~~TOTAL WASTE QUANTITY~~		~~0~~	~~1~~	~~2~~	~~3~~	~~5~~		~~15~~
~~WASTE INCOMPATIBILITY~~		0	1	2	3	5		15
USE OF LINERS	Bentonite	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	2	[✓ 3]	3	9	9
USE OF GAS COLLECTION SYSTEMS	N/A	[✓ 0]	1	2	3	2	0	6
USE AND CONDITION OF CONTAINERS	None	0	1	2	[✓ 3]	2	6	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								~~30~~
						SUBTOTALS	15	72
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		21

NUMBER OF MISSING AND ASSUMED VALUES = 2 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 25 %.

NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 9.67 %

TOTAL FACTOR SCORE 251

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 455

OVERALL SCORE 55
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE LANDFILL #2; FACILITY: K025.1 WASTE

WASTE CHARACTERISTICS								
TOXICITY	Meta-dinitrobenze, 2, 4-dinitrobenzene	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE		0	1	[✓ 2]	3	5	10	15
IGNITABILITY		0	1	[✓ 2]	3	3	6	9
REACTIVITY		0	1	2	[✓ 3]	3	9	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		[✓ 0]	1	2	3	4	0	12
VOLATILITY		0	1	2	3	~~4~~		~~12~~
PHYSICAL STATE		0	1	[✓ 2]	3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS							4	20

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 11.1 %.

SUBTOTALS	58	128
SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		45

WASTE MANAGEMENT PRACTICES								
SITE SECURITY		[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY	Locked Fence	[✓ 0]	1	2	3	7	0	21
TOTAL WASTE QUANTITY		~~0~~	~~1~~	~~2~~	~~3~~	~~5~~		~~15~~
WASTE INCOMPATIBILITY		~~0~~	~~1~~	~~2~~	~~3~~	~~5~~		~~15~~
USE OF LINERS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF LEACHATE COLLECTION SYSTEMS	Yes	[✓ 0]	1	2	3	3	0	9
USE OF GAS COLLECTION SYSTEMS		0	1	2	3	2		6
USE AND CONDITION OF CONTAINERS	Good	[✓ 0]	1	2	3	2	0	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								30

NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 37.5 %.

SUBTOTALS	0	66
SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		0

NUMBER OF MISSING AND ASSUMED VALUES = 5 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 16.1 %

TOTAL FACTOR SCORE 195

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 437

OVERALL SCORE 45
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)

NAME OF SITE LANDFILL #3: FACILITY K025.1 WASTE

WASTE CHARACTERISTICS

TOXICITY	Meta-dinitrobenzene, 2,4-dinitrotoluene	0	1	2	[✓ 3]	7	21	21
RADIOACTIVITY		[✓ 0]	1	2	3	7	0	21
PERSISTENCE		0	1	[✓ 2]	3	5	10	15
IGNITABILITY		0	1	[✓ 2]	3	3	6	9
REACTIVITY		0	1	2	[✓ 3]	3	9	9
CORROSIVENESS		[✓ 0]	1	2	3	3	0	9
SOLUBILITY		[✓ 0]	1	2	3	4	0	12
VOLATILITY		~~0~~	~~1~~	~~2~~	~~3~~	~~4~~		~~12~~
PHYSICAL STATE		0	1	[✓ 2]	3	4	8	12
ADDITIONAL POINTS FOR OTHER WASTE CHARACTERISTICS	Carcinogenic						4	20
						SUBTOTALS	58	128
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		45

NUMBER OF MISSING AND ASSUMED VALUES = 1 OUT OF 9.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 11.1 %.

WASTE MANAGEMENT PRACTICES

SITE SECURITY	Fence, guard	[✓ 0]	1	2	3	7	0	21
HAZARDOUS WASTE QUANTITY		[✓ 0]	1	2	3	7	0	21
TOTAL WASTE QUANTITY		~~0~~	~~1~~	~~2~~	~~3~~	~~5~~		~~15~~
WASTE INCOMPATIBILITY		~~0~~	~~1~~	~~2~~	~~3~~	~~5~~		~~15~~
USE OF LINERS	None	0	1	2	[✓ 3]	3	9	9
USE OF LEACHATE COLLECTION SYSTEMS	None	0	1	[✓ 2]	3	3	6	9
USE OF GAS COLLECTION SYSTEMS		~~0~~	~~1~~	~~2~~	~~3~~	~~2~~		~~6~~
USE AND CONDITION OF CONTAINERS		0	1	2	3	2	2	6
ADDITIONAL POINTS FOR OTHER WASTE MANAGEMENT PRACTICES								30
						SUBTOTALS	17	56
						SUBSCORE (FACTOR SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)		26

NUMBER OF MISSING AND ASSUMED VALUES = 3 OUT OF 8.

PERCENTAGE OF MISSING AND ASSUMED VALUES = 37.5 %.

NUMBER OF MISSING AND ASSUMED VALUES = 7 OUT OF 31

PERCENTAGE OF MISSING AND ASSUMED VALUES = 22.58 %

TOTAL FACTOR SCORE 183

TOTAL MAXIMUM POSSIBLE FACTOR SCORE 407

OVERALL SCORE 45
(TOTAL SCORE DIVIDED BY MAXIMUM SCORE AND MULTIPLIED BY 100)